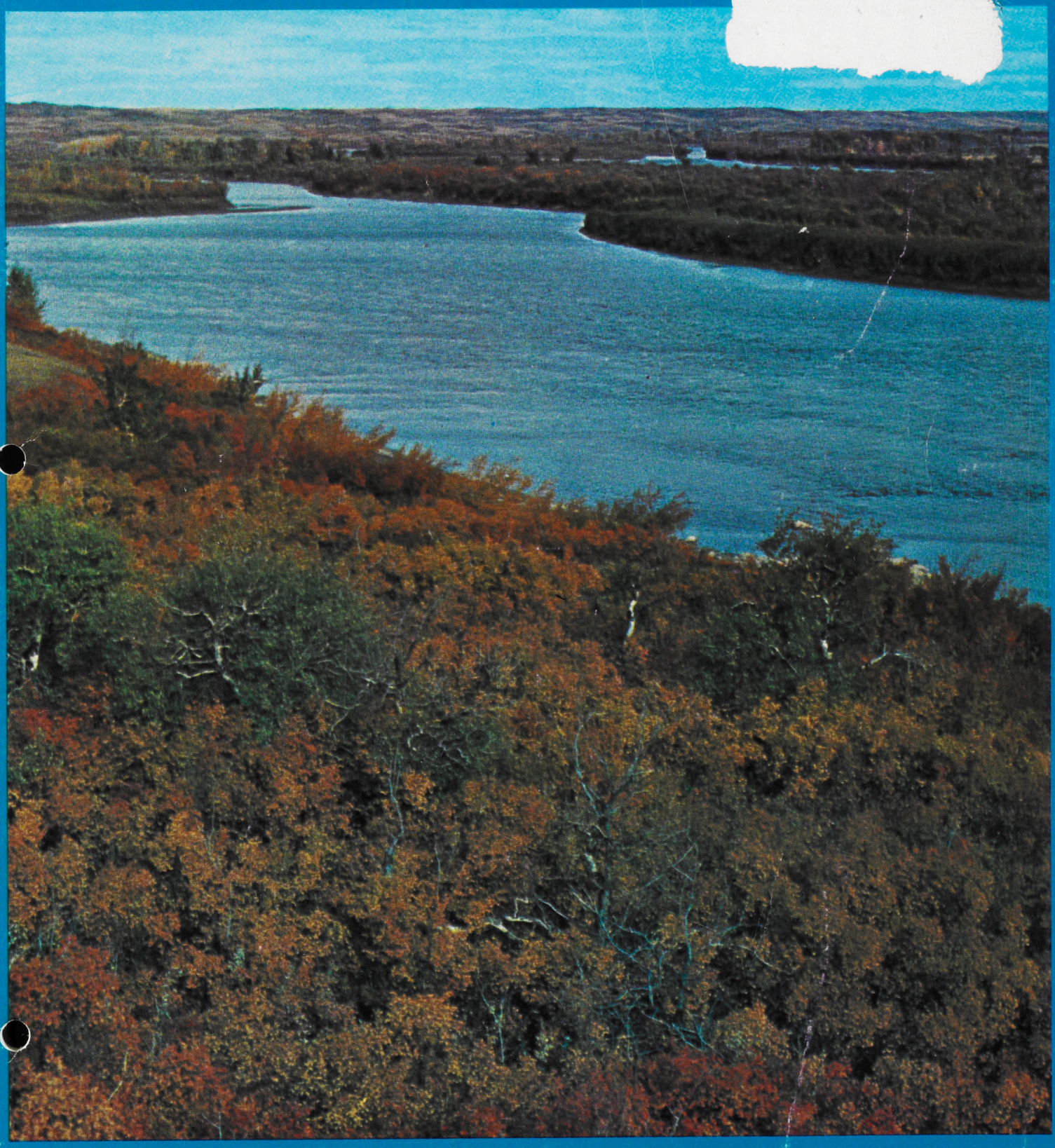
GUIDE TO FARM PRACTICE in Saskatchewan 1972



MEASURES AND WEIGHTS FOR AGRICULTURAL PURPOSES

Measuring Grain in a Rectangular Bin

NOTE: One cubic foot is equal to approximately 0.78 of 1 bushel.

The number of bushels of grain in a bin may be determined as follows:

1. Level the grain in the bin.
2. Multiply the length of bin by the width by the depth of grain in feet. This gives the cubic content of the bin.
3. Deduct the cubic contents of any studding inside the dimensions taken.
4. Multiply the results by 0.78. This gives the bushels by measure.
5. Change to bushels by weight by multiplying by the weight of grain per bushel and dividing by the legal weight per bushel.

EXAMPLE: A bin is 12 feet long, 10 feet wide, and the grain when levelled is 8 feet deep. It has 18-2-inch by 4-inch uprights inside of the bin. The wheat weighs 65 pounds per measured bushel.

$$(12 \times 10 \times 8) - \frac{(18 \times 2 \times 4 \times 8)}{12 \quad 12} = 960 - 8 = 952 \text{ c.ft.}$$

$$\frac{952 \times 78}{100} = 742.56 \text{ bushels by volume}$$

$$\frac{742.56 \times 65}{60} = 804.44 \text{ bushels by weight}$$

Measuring Grain in a Round Bin

The area of floor may be determined by squaring one-half of the diameter and multiplying by 22/7.

EXAMPLE: A round bin 12 feet wide contains oats to a depth of 8 feet weighing 40 pounds per bushel.

One half diameter=6 feet

$$\frac{6 \times 6 \times 22}{7} = 113.14 \text{ square feet}$$

$113.14 \times 8 = 905.12$ cubic feet

$$\frac{905.12 \times 78}{100} = 706 \text{ bushels by volume}$$

$$\frac{40 \times 706}{34} = 830.5 \text{ bushels by weight.}$$

Measuring Grain in a Cone-Shaped Pile

1. Determine the circumference at the base by measuring (in feet).
2. Multiply this figure by 7/22 to obtain the diameter.
3. Divide this figure by 2 to determine the radius.
4. Determine by measurement the distance (in feet) from the bottom of the pile to the peak = slope.
5. Determine the depth of the pile as follows: Slope squared — radius squared = depth squared. Extract the square root of depth squared = depth.
6. Volume = ⅓ of 22/7 X radius squared X depth.
7. To change volume from cubic feet to bushels by measure, multiply by 78 and divide by 100.
8. Adjust to bushels by weight as previously explained.

Measuring Hay and Straw in Stacks

The approximate number of tons of hay or straw in a stack may be determined as follows:

1. Estimate the number of cubic feet in the stack.
2. Determine the number of tons in the stack by dividing the number of cubic feet in the stack by the number of cubic feet per ton as follows:

a. Alfalfa, sweet clover, and wild hay.

Days in Stack	Cubic feet per ton
30	548
60	520
90	504
120	492
150	480
180	472
240	456
300	440

b. Brome Grass Hay.

Allow about 25 percent more cubic feet per ton than in a. above.

c. Straw.

It requires at least 1200 cubic feet of well-settled straw to weigh 1 ton.

Legal Bushel Weight of Saskatchewan Crops

	lb
Wheat, alfalfa seed, clover seed, beans, peas, potatoes	60
Rye, flax seed, corn	56
Rapeseed	50
Barley, buckwheat, timothy seed	48
Hemp seed	44
Oats	34
Crested wheatgrass seed	22
Brome grass and western rye grass seed	14
Bluegrass	18

Measures and Conversion Factors

Land

1 Link=7.92 inches
1 rod=25 links=5½ yards=16½ feet
1 chain=100 links=66 feet
1 mile=80 chains
1 square rod=30¼ square yards
1 acre=160 square rods=4840 square yards
1 square mile=640 acres

Volume

1 peck=2 gallons=8 quarts=16 pints
1 bushel=4 pecks=8 gallons
1 imperial gallon=1.20 (6/5) U.S. gallons
1 cubic foot=6.23 gallons
1 bushel=1.28 cubic feet
1 cubic foot=0.78 bushel
1 cubic foot water=62.5 pounds
1 gallon water=approximately 10 pounds

Guide to Farm Practice in Saskatchewan 1972

Prepared jointly under the
SASKATCHEWAN AGRICULTURAL SERVICES CO-ORDINATING COMMITTEE
by representatives of the
UNIVERSITY OF SASKATCHEWAN
SASKATCHEWAN DEPARTMENT OF AGRICULTURE
CANADA DEPARTMENT OF AGRICULTURE

Publication financed jointly by the
CANADA AND SASKATCHEWAN DEPARTMENTS OF AGRICULTURE

Publication edited and prepared by the
EXTENSION DIVISION
UNIVERSITY OF SASKATCHEWAN, SASKATOON

FOREWORD

Purpose

The primary purpose of the **Guide to Farm Practice in Saskatchewan** is to improve farm income. To do this the **Guide** has the following objectives:

1. To help farmers understand the basic principles and practices of farming.
2. To provide them with a ready reference on recommended production and management practices for day-to-day operations and for meeting special problems.
3. To assist teachers and rural leaders in the preparation of instructional material for agricultural courses and programs.
4. To assist agricultural advisors and consultants in assessing current theories and principles of farm practice, in keeping abreast of recommended practices, and in helping farmers apply them.

Information Available

The **Guide** contains the pooled findings and recommendations of technical workers in Saskatchewan agriculture. All sections were prepared by representatives of the participating agencies working in Advisory Councils and committees of the Saskatchewan Agricultural Services Co-ordinating Committee. (See Services, page 163.)

Since publication is at 3-year intervals some recommendations will change before the next issue appears. In view of this, care should be taken to check on approved recommendations from time to time.

More detailed, and at times more up-to-date, agricultural production and management information is contained in bulletins available from the nearest agricultural representative office (page 163), from the Extension Division, University of Saskatchewan, Saskatoon, or from the Canada Department of Agriculture Experimental Farm at Indian Head, and Research Stations at Melfort, Regina, Saskatoon, and Swift Current.

Subscriptions to the periodicals **Saskatchewan Farm Science, Gardeners' Bulletin,** and **Homes and Families** may be obtained from the Extension Division, University of Saskatchewan.

Newsletters are prepared by some research stations and agricultural representatives.

A summary of services appears on page 163. Inquiries should be sent to the addresses indicated or, if in doubt, see your agricultural representative.

History

In 1932 a comprehensive plan was drafted by the Minister of Agriculture for Canada to co-ordinate on a national scale all federal and provincial government services available to farmers. The plan involved a National Advisory Committee and a co-operating Advisory Committee in each province. The Saskatchewan Advisory Committee was named early in 1933 and the Agricultural Conference in January of that year was held under its direction. The Conference dealt with every phase of agricultural production and the 1933 report went out under the title **Guide to Saskatchewan Agriculture.**

Agricultural conferences were held every 3 years from 1933 to 1968. On each occasion the resulting **Guide** presented a revision of the previous material as well as new information the conference thought would add to its usefulness. In 1939 the name of the publication was changed to **Guide to Farm Practice in Saskatchewan.**

Beginning with the 1972 **Guide,** a conference was not held to co-ordinate publication. Henceforth, the **Guide** will be a product of various Advisory Councils and committees of the Saskatchewan Agricultural Services Co-ordinating Committee.

CONTENTS

THE AGRICULTURAL CLIMATE OF SASKATCHEWAN

Agriculture and climate are closely related. The past climate helped form our rich soils. The present climate determines the types and varieties of crops which may be grown. Drought and excessive rainfall, frost and intense heat, each typical of our climate, are major risks in farming. Almost every farming operation is, in some measure, linked with climate.

Man has had to struggle with his climatic environment throughout the centuries. On the Prairies the struggle has been particularly difficult. It has been necessary to adjust to blizzards and bitter cold while living in relative isolation, and to find methods of conserving both surface-water and soil-moisture supplies. Frost, heat, wind, and dust have created challenges which have had to be met.

The success of agriculture has depended on our ability to cope with the climate. This had been done in crop production through the breeding of new varieties, through conservation practices, and through the intelligent use of climatic data. Climatic data have also been used in making life more secure and comfortable, for example, in determining insulation requirements for houses, the strength of roof supports, the size of heating systems, and the proper design of water-supply systems. Information about present and future weather has been applied widely in determining such farm operations as seeding, cultivation, harvesting, shipping, and maintenance. The struggle with climate continues, but living has become more pleasant and rewarding as our technology and understanding of weather and climate improve.

Weather may be considered as the sequence of atmospheric events taking place at a specific hour or on a particular day. Climate, on the other hand, is the accumulated experience of all weather events at a particular place.

People tend to consider weather and climate as a series of hazards, and to ignore the favorable aspects. Weather is a resource. Light, heat, and precipitation are necessary to make our fertile soils productive. Saskatchewan has been particularly favored by a combination of sunlight, temperature, and precipitation that has earned it world renown for grain production. The precipitation is generally so distributed that most of it occurs just when it is most required by crops, leaving sunny, dry weather for maturing and harvesting. Saskatchewan is richly endowed by nature, but the economic return is in proportion to how well we use this natural resource. Climatic studies indicate how much energy is available from the sun, how much moisture is available for food production, and the character of weather risks. An understanding of these features of climate enables both climatic data and weather forecasts to be used to greater benefit in farm operations.

CROP PRODUCTION

The influence of weather is most evident in crop production. Productivity depends on how well the climate satisfies the biological needs of crops. These vary from one type of plant to another, each usually requiring a particular combination of light, heat, and moisture.

Light

Light affects plants in all stages of growth. Sunlight warms the soil and thereby promotes germination. Emerging plants, when exposed to light, quickly form the green pigment, chlorophyll, which, along with light, is essential for food production. Plants respond differently to both intensity and duration of light. Those in excessive shade tend to have weak stems and poorly developed leaves, while those in an abundance of light tend to have short, strong stems and well-developed leaves. Certain plants, such as asters, flower more readily when days are short; others, such as timothy and rye grass, flower more readily when days are long. Still others, such as the tomato, are not sensitive to day length. Long days and high temperatures favor growth of the potato plant, but somewhat shorter days and lower temperatures favor greatest tuber production.

The response to light is complex, and must be considered in its relation to temperature and other factors. For certain crops long day length may compensate for low temperatures. Wheat, like timothy, is a long-day plant; however, its response to day length and temperature is highly variable according to variety. Wheat that requires 106 days to reach the headed stage from emergence in Mexico, where the average day length is 11.6 hours, takes only 33 days in Fairbanks, Alaska, where the day length is 20.3 hours.

Air Temperature

Plant growth is restricted to a range of air temperatures. The temperature at which growth begins and is arrested, and the best temperatures for growth, are called "Cardinal Growth Temperatures." Examples are given in Table I.

TABLE I

Cardinal Growth Temperatures
Temperatures in °F

CROP	Wheat	Oats, Barley	Flax	Sweet Corn	Tomatoes	Potatoes	Beans
Lower Limit	32	39	35	50	60	45	50
Optimum	84	65–75	75–80	75–90	70–75	60–65	60–70
Upper Limit	108	85	86	95	80	70–75	80

The effects of temperature on growth are as varied as those of light. As may be seen from the table, wheat is more tolerant of high temperature than oats. The seasonal march of temperature is important in the life of some plants. For example, biennials such as the carrot and beet will not go to seed unless they experience a period of cold weather. Beets will grow for years, reaching a tremendous size, in an area where there is no marked seasonal temperature change. Daily temperatures and their variations are also important. Sugar beets, for example, grow most rapidly with a nighttime temperature of 68°F, but such beets are low in sugar content. Highest sugar content is obtained when night temperatures are very low. Also, in considering temperature, the effects of freezing or excessive heat, which may damage plants, must not be overlooked.

Growing Degree-Days—Temperature is a good index of the amount of energy available to plants from the sun. The past record of temperature is, therefore, a good measure of a plant's state of maturity. Growing degree-days, sometimes called "heat units" are the accumulation of daily mean air temperatures above a certain base value. (See Table II.) For example, if the daily average temperature were 62°F, the number of growing degree-days for that day would be 62-42=20. Over a season the accumulation of these values may reach a substantial figure, e.g.,

about 2,900 at Moose Jaw. Maps of seasonal accumulations of growing degree-days can be used to see if a particular crop is likely to mature in a given area. In principle, accumulation of growing degree-days can be used to plan seeding operations. However, the situation is complicated by the fact that some crops, including wheat, respond to day length as well as accumulated growing degree-days.

The value of 42°F is frequently used for horiculture in general. It was used to prepare the map of accumulated degree-days shown as Fig. 1. Accumulations for the Prairies are generally adequate for the maturing of spring wheat, and also allow for a good harvest period. (See Table III.)

TABLE II

Base Temperatures Used to Compute Growing Degree-Days

Spring Wheat	42°F
Canning Peas	40°F
Oats	43°F
Potatoes	45°F
Sweet Corn	50°F
Tomatoes	60°F
Field Corn	55°F
Horticulture in general	42°F

However, some caution must be used, particularly in northern farm areas, regarding these growing degree-day values. In the first place, a fraction, about 10 percent of the total, is accumulated too soon or too late in the season to actually aid in crop growth. Secondly, they represent averages, and in any one year the total may be less than average by as much as 15 percent. Thus in any area shown in Fig. 1 to have 2,300 or fewer growing-degree days, there may be maturing problems for wheat in cool years.

TABLE III

Degree-Day Accumulations Above 42°F for the Growth of Spring Wheat

Location	Years of Data	Sown to Headed	Headed to Ripe	Total (Sown to Ripe)
Indian Head	21	890	880	1770
Melfort	16	865	911	1776
Saskatoon	11	847	892	1739
Scott	17	855	875	1730
Swift Current	18	895	909	1804
Regina	8	869	835	1704

Air-Temperature Variation and Measurement—Air temperature varies daily and seasonally as determined primarily by the sun. Major atmospheric movements and the general and local environment also affect it. Temperatures vary locally because of differences in vegetative cover, topography, or such other factors as nearness to a lake. Hollows have relatively low temperatures at night; hilltops have relatively low temperatures in the afternoon. South-facing and west-facing slopes tend to be several degrees warmer than north- and east-facing slopes. In some specialized areas these small-scale climatic variations have been mapped to help obtain optimum agricultural output.

Sustained winds from colder or warmer regions cause abnormal temperatures. Winds also produce air turbulence, thereby causing lower daytime (and higher nighttime) temperatures than would otherwise occur.

Clouds and atmospheric moisture also influence temperature. Clouds, by reducing the amount of energy reaching the ground from the sun, depress daytime temperatures. They also reduce the amount of heat lost from the earth at night. Atmospheric moisture acts somewhat the same as clouds. In addition, the formation of dew and fog also helps to keep overnight temperatures from dropping.

In autumn, light soils are cooled quickly by radiation and uptake of cold rain, while heavy soils remain relatively warm.

The temperature referred to in most of this discussion is measured in a ventilated shelter placed about 4 feet above a grassy surface. Measurement is made at this height to obtain a value which is more representative of a general area and is not unduly influenced by the ground and the immediate surroundings. Major differences can and do exist between temperatures recorded in the shelter and those which occur at a leaf's surface, or on the ground. This is particularly noticeable on calm, clear nights when freezing temperatures may occur on the ground or in the plant canopy, but not in the weather shelter higher above the ground surface.

The characteristics of air temperature for selected Saskatchewan locations are given in Table IV. The highest temperature recorded in the province is 113°F, occurring at Yellowgrass and Midale in July, 1937; the lowest is -70°F at Prince Albert in February, 1893.

Temperature Control—Air temperatures can be modified, but this is usually practical only over very small areas. Temperatures may be controlled through shading from trees or fences. Downwind from the shaded area, however, shelterbelts increase temperatures by several degrees over a distance equal to several times the height of the trees. Sprinkler irrigation during the afternoon reduces air and soil temperatures, and has been used to lessen the strain on plants during hot, dry afternoons. Various devices used in frost prevention are discussed later.

TABLE IV

Air Temperature

	JANUARY					JULY				
Locations	Av. Daily	Av. Daily Max.	Av. Daily Min.	Ext. Max.	Ext. Min.	Av. Daily	Av. Daily Max.	Av. Daily Min.	Ext. Max.	Ext. Min
Assiniboia	6e	17e	−5e	54e	−54e	67	81	54	108	34
Estevan	5	14	−4	51	−44	68	81	56	110	31
Hudson Bay	−4	6	−13	46	−50	64	76	52	96	31
Humboldt	−3	6	−11	47	−59	65	77	52	106	32
Leader	6	15	−4	59	−52	68	84	52	106	29
Lintlaw	−3	7	−13	43	−54	63	75	50	103	25
Loon Lake	1	12	−10	55	−59	62	76	48	98	27
Macklin	2	11	−7	48	−51	65	79	51	103	26
Maple Creek	13	25	1	66	−53	68	82	53	105	31
Melfort	−2	7	−12	58	−52	65	78	52	106	30
Moose Jaw	6	16	−4	57	−53	68	82	55	110	32
Nashlyn	7	19	−5	57	−55	66	83	49	108	30
Nipawin	−5	5	−13	52	−55	66	79	53	108	30
North Battleford	0	9	−9	52	−61	66	78	53	103	32
Outlook	4	13	−6	51	−51	68	81	54	106	32
Prince Albert	−3	7	−13	55	−67	65	77	53	103	33
Regina	2	11	−8	48	−54	67	80	53	110	28
Rosetown	2	11	−7	50	−53	66	79	52	111	27
St. Walburg	−3	9	−14	48	−65	62	77	48	100	24
Saskatoon	1	10	−8	48	−55	67	79	54	104	32
Spiritwood	−2	10	−14	52	−62	62	77	47	103	26
Swift Current	9	18	0	52	−45	67	79	55	100	38
Val Marie	7	19	−6	54	−57	67	83	50	106	31
Whitewood	2	11	−7	46	−48	65	78	52	106	32
Yorkton	−2	7	−10	47	−51	66	77	54	105	30

e—Estimated. Av.—Average. Ext.—Extreme.

Precipitation

The amount of precipitation (rainfall and snowfall) required for successful agriculture varies with the type of plant, the soil, and other climatic factors. Soils have different moisture-holding capacities. Sandy soils, which hold little water, tend to be dry. Clay soils, which may hold much more, tend to be productive even in dry periods. Crops grown in cooler, more humid areas may require somewhat less moisture than those of equal yield grown in warmer, drier areas.

Moisture requirements for top yields of various crops, utilizing maximum fertility levels, are shown in Table V.

TABLE V

Seasonal Water Requirements

Crop Type	Average Water Use	Length of Growing Season
	(in.)	(days)
Alfalfa	25	155
Grass	24	150
Sugar Beets	22	155
Potatoes	20	140
Hard Wheat	18	100
Oats	16	95
Barley	16	90
Flax	15	100
Field Corn	15	120
Tomatoes	14	105
Canning Peas	13	80

Plants obtain moisture from melting snow, rain, and irrigation. The average growing-season rainfall in Saskatchewan ranges from about 7 to 11 inches, as shown in Fig. 2. The rest of the requirement for best crop conditions must therefore come from moisture previously stored in the soil by snowfall or fallowing, or from irrigation.

Rainfall varies markedly from season to season. This variation from year to year and the importance of precipitation in crop production are shown for Swift Current in Fig. 3. Since the yield depends partly on soil-moisture reserves built up by autumn rains and snows, precipitation records covering the crop year (August 1 to July 31) have been used. Over a 45-year period, crop-season precipitation ranged from 7.3 to 20.4 inches. Although the normal precipitation is 13.5 inches, less than 10 inches fell in 9 of these years. Imperfect timing of rainfall, disease, and other factors also affect yield, so that yield and precipitation amounts are not always in close agreement.

Snowfall and the Winter Snow Cover—Snowfall provides most of the surface-water supply, and helps restore soil moisture and ground water. It therefore plays a vital role in Western Canada.

The average winter snowfall ranges from 25 inches in the southwest to nearly 55 inches in the northern and eastern areas. Winter thaws frequently remove the snowpack in the southwest, but it tends to remain throughout the winter elsewhere.

The snow cover prevents the soil from drying out, and prevents soil erosion. In one investigation, fields with snow cover yielded 50 percent more oats than nearby fields without cover. The amount of snow that melts and goes into soil, or runs off into dugouts, depends not only on the amount of snow present, but also on how rapidly it melts, and the state of the soil at the time.

Rapid melting favors maximum surface runoff; a slow, extended thaw favors penetration into the soil of a greater percentage of the snow-melt. Generally, a heavy snowpack is a reasonable guarantee of a good soil-moisture supply, and may be used as a guide in fertilizing.

Snow is an excellent insulator, and a good snow cover may prevent winterkill from extreme temperatures. At the same time, however, it protects insects and moulds which may damage crops. A deep snowpack restricts foraging, and ice crusts which form on the snow may injure livestock.

Snow Management—The snowfall may be managed to increase useful water supplies. Snow readily blows off exposed areas to accumulate in gullies, or near obstacles which disturb the wind. By strategically locating fencing, equipment, or hedges, snow can be made to accumulate over a dugout or its drainage area, thereby increasing surface-water supplies. The same principle may be applied to keep feedlots, roads, and working areas relatively free from snow.

Snow accumulation on fields may be increased by maintaining stubble or a cover or catch crop, and possibly by plowing or windrowing the snow. Shelterbelts are also effective in retaining the snow cover and in extending the melting period.

Rainfall—Rainfall provides most of the crop-moisture requirements. In Saskatchewan, where the supply is critical, the right timing of rainfall is important. The heaviest rainfalls in Saskatchewan usually occur in June, the month of maximum growth. (See Table VI.) However, sufficient rainfall cannot always be relied on.

Studies at Swift Current have shown that July rainfall provides the best indicator of any single month for crop yield. High June rainfall does not guarantee high yields. On the other hand, May precipitation trends point to the advantage of early seeding to take advantage of surface moisture for germination.

Rainfall Control—Weather control has not yet been developed to the point where cloud seeding or other devices can be relied on to increase rainfall over the Prairies. In drought years, clouds suitable for seeding are rare; even if effective, cloud seeding would still be unlikely to give useful increases in rainfall when most needed.

Conservation is the best answer to rainfall deficiencies for land areas. The runoff of rainfall into surface storage may be increased by waterproofing the drainage area and by using the natural slope of the land. Infiltration may be increased by cultivation practices, by contour plowing, and by otherwise preventing water from running off fields. (See Agricultural Engineering section, "Farm Dugouts.")

Evaporation

Most rainfall is returned to the atmosphere through transpiration by plants and evaporation from the soil and water surfaces. Plant water use under ideal conditions has been given in Table V; under dry soil conditions plants use less moisture. Evaporation from water surfaces is usually from 2 to 3 feet of water annually with the highest losses

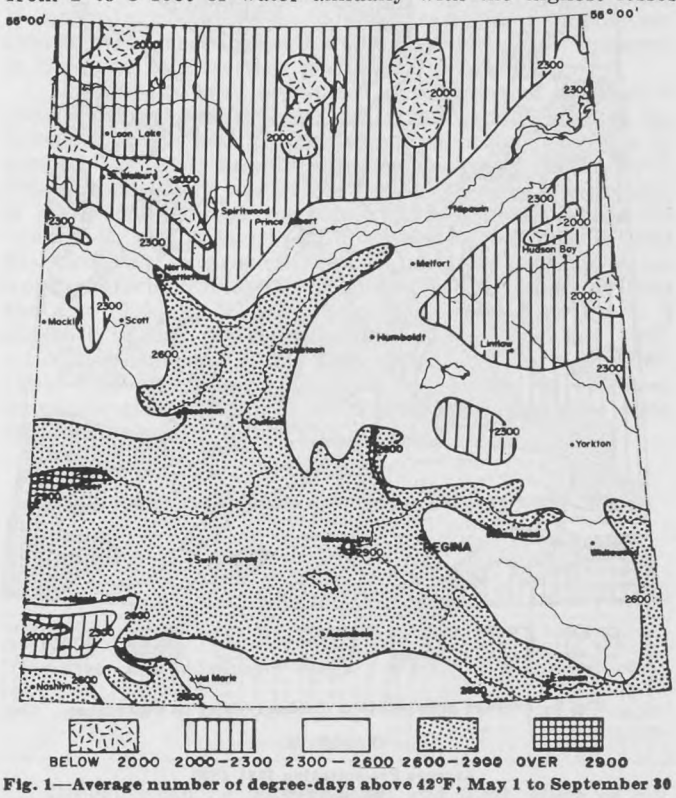


Fig. 1—Average number of degree-days above 42°F, May 1 to September 30

Note: Degree-days are computed as follows—when the daily mean temperature is 62°F, there are 62 - 42 = 20 growing degree-days for that day. The values shown are totals for 153 days of the growing season.

occurring in the arid southwest. Nearly 1 foot of the loss is restored by summer rainfall. Evaporation often exceeds other water use. It is greatest (less than 4 feet) in hot, dry years when there is usually little rainfall to compensate for the loss and when farm water consumption also reaches its peak. Evaporation losses must be considered when planning for water storage such as dugouts or stock-watering ponds. Water supplies should be adequate to cope with the combined loss by evaporation and farm use that may be expected over a drought period.

Research is being carried out on chemicals which suppress evaporation to see if they can be used economically to conserve surface-water supplies. The general experience has been that the suppressants have little effect when winds are over 15 mph, and also that their efficiency decreases as temperatures increase. The prevalence of strong winds limits their effectiveness on the Prairies.

WEATHER HAZARDS

Prairie weather, while excellent in general for grains, is highly variable, so that crops are continually exposed to climatic risks. Frost, drought, and wet harvest seasons are well-recognized problems.

Frost

Although frosts may occur in any month, it is usually those late in spring and early fall that are critical. Frost is the deposit of white ice crystals that forms on plants or objects during cold nights. On very dry nights plants may freeze without visible frost forming; on the other hand, a frost cover on a leaf does not necessarily mean the leaf has been damaged. Damage occurs when ice crystals form within the plants, or the plant actually freezes. For this reason the terms "freeze" and "freeze damage" are often preferred to "frost" and "frost-damage."

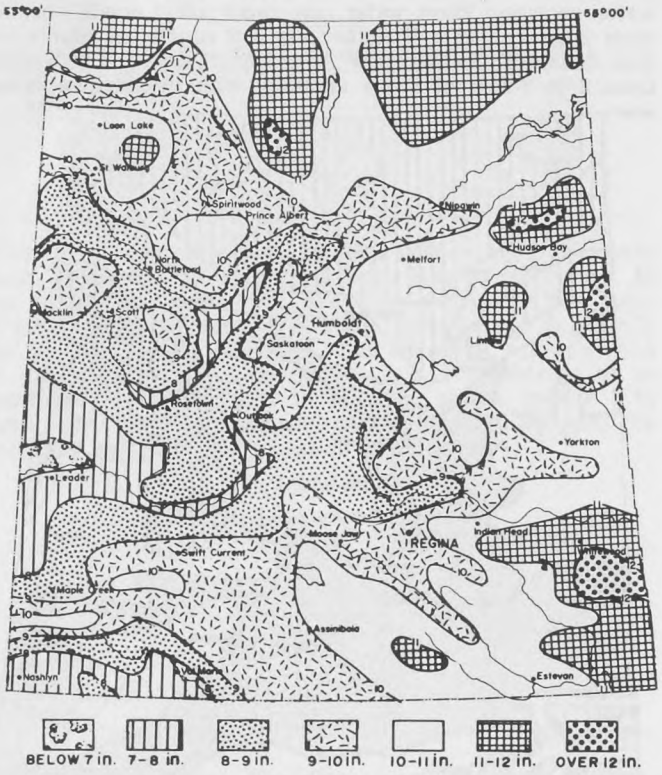


Fig. 2—Average precipitation (inches)—May to September

TABLE VI

Average Precipitation 1931-1960
(in. of water)

LOCATION	MONTH J.	F.	M.	A.	M.	J.	J.	A.	S.	O.	N.	D.	Total for Year
Assiniboia*	0.7	0.6	0.7	0.9	1.7	3.4	2.2	1.8	1.3	0.7	0.6	0.6	15.2
Estevan	0.7	0.6	0.8	0.9	1.6	3.5	2.3	1.9	1.5	1.0	0.9	0.7	16.4
Hudson Bay	0.8	0.6	1.0	1.1	1.5	2.9	2.8	2.3	1.7	0.9	1.3	0.8	17.5
Humboldt	0.5	0.3	0.8	0.9	1.2	2.8	1.9	1.6	1.2	0.7	0.6	0.5	13.2
Leader	0.6	0.5	0.7	0.9	1.2	2.5	1.6	1.4	1.1	0.7	0.6	0.5	12.1
Lintlaw	0.7	0.6	0.8	1.1	1.6	3.2	2.3	2.1	1.7	1.0	1.0	0.8	16.7
Loon Lake	0.7	0.5	0.8	0.8	1.5	2.7	2.8	2.4	1.7	1.0	0.8	0.8	16.5
Macklin	0.6	0.5	0.6	0.8	1.2	2.3	2.3	2.0	1.2	0.8	0.4	0.7	13.5
Maple Creek	0.8	0.8	0.6	0.9	1.4	2.5	1.6	1.5	1.3	0.7	0.8	0.6	13.6
Melfort	0.8	0.6	0.9	0.9	1.4	2.8	2.4	1.9	1.6	1.0	1.1	0.7	16.1
Moose Jaw	0.8	0.6	0.8	0.9	1.7	3.0	2.0	1.9	1.2	0.6	0.7	0.8	14.9
Nashlyn	0.5	0.4	0.5	0.7	1.1	2.3	1.3	1.2	0.8	0.5	0.4	0.4	10.0
Nipawin	0.6	0.5	1.0	1.0	1.6	2.7	2.3	2.1	1.5	1.0	1.2	0.8	16.3
North Battleford	0.7	0.5	0.6	0.8	1.3	2.2	2.2	1.7	1.2	0.9	0.7	0.8	13.7
Outlook	0.5	0.5	0.5	0.6	1.2	2.6	1.9	1.3	1.2	0.6	0.4	0.4	11.7
Prince Albert	0.7	0.6	0.7	1.0	1.6	2.6	2.2	1.9	1.4	1.0	1.1	0.9	15.8
Regina	0.6	0.6	0.7	0.8	1.6	3.2	2.2	1.9	1.3	0.7	0.7	0.6	14.9
Rosetown	0.6	0.5	0.5	0.9	1.2	2.5	2.3	1.7	1.3	0.8	0.5	0.6	13.3
St. Walburg	0.5	0.5	0.6	0.8	1.2	2.1	2.6	2.3	1.1	0.8	0.6	0.7	13.8
Saskatoon	0.6	0.6	0.6	0.8	1.3	2.3	2.4	1.8	1.3	0.7	0.7	0.7	13.8
Spiritwood	0.6	0.4	0.7	0.9	1.2	2.2	2.3	2.1	1.3	0.7	0.7	0.8	14.0
Swift Current	0.8	0.6	0.7	1.0	1.6	3.1	2.1	1.8	1.3	0.8	0.8	0.7	15.3
Val Marie*	0.7	0.6	0.6	0.9	1.3	2.4	1.4	1.1	0.6	0.4	0.5	0.5	11.0
Whitewood	0.8	0.6	1.0	0.9	1.8	3.6	2.4	2.6	1.6	0.9	1.0	0.7	17.8
Yorkton	0.8	0.6	1.1	0.9	1.5	3.1	2.6	2.3	1.6	0.8	1.0	0.9	17.1

*Values for Assiniboia and Val Marie from November to March are estimated.

The temperature at which freezing occurs varies with the type of plant, its state of maturity, and other factors. This and previously noted variability of temperatures near the ground make it very difficult to provide a good estimate of freeze damage from measurements of air temperature. Meteorological measurements are made at 4 feet above the ground. For simplicity, temperatures of 32°F or less at this level are accepted as constituting a frost. Actually, leaf and ground-level temperatures may be much lower than the recorded value, and freezing of plants has occurred when 4-foot temperature was 40°F.

Subject to the above limitations, plant response to frost is as follows: tender plants such as cucumbers and tomatoes are damaged when the air temperature drops to the 34° to 30°F range; fruit-tree blossoms, sugar beets, onions, and potatoes are damaged when temperatures fall to the 29° to 25°F range; most annuals are killed and perennials made dormant when the temperature drops to less than 25°F.

The duration of the freeze period is important. A very short frost may not hurt crops, while one that lasts all night may damage them severely. The rate at which the temperature drops and rises also appears to be important. Several days of near-freezing temperatures may harden plants and prevent serious damage.

Most late-spring and early-fall frosts result from the cooling of the ground when skies are clear and winds light. The air in contact with the ground may then become many degrees colder than the air several feet above. Under these conditions, the colder air will follow the natural drainage of the land, and accumulate in pockets or frost-hollows. These pockets are favored locations for unseasonal frosts.

Frost risks are increased uphill from a barrier to natural air flow, and lessened below the barrier. Both trees and land may form barriers that create frost pockets.

Winds may prevent the occurrence of frosts by mixing the cold air near the ground with warmer air from above. In addition, clouds act as a blanket and reduce the loss of heat from the ground. A layer of moist air near the ground may be almost as effective as a cloud. Moist air also favors dew formation, which releases heat. The flow of heat from the ground may also offset a frost.

Soils that are light in color and reflect sunlight tend to remain cool during the day and therefore have a relatively low heat content; porous soils also are unable to transfer heat rapidly to the surface, and are more susceptible to frost.

The main conditions that favor frost are:

1. Sheltered from the sun by day, open exposure to the night sky; 2. cloud cover by day, clear skies at night; 3. dry air, relative humidity below 40 percent at 6 p.m.; 4. calm or light winds, possibly preceded by sustained strong northerly wind; 5. dry soil, particularly organic soils.

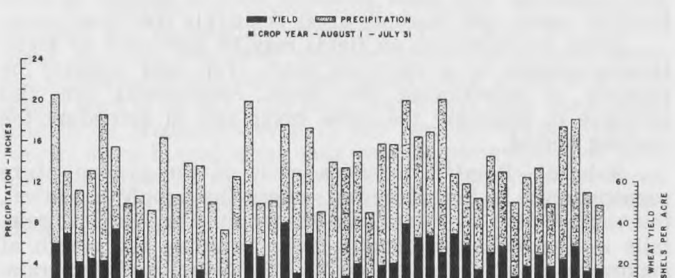


Fig. 3—Crop year precipitation and wheat yield, Swift Current, 1923-1967

A map of the average length of the frost-free season is presented as Fig. 4. For many plants the season is barely sufficient to reach maturity. The values given are typical of an area. However, within areas large variations may occur; for example, places enclosed by hedges or trees have been found 5 to 10 degrees colder on a frosty night than places exposed to the wind, and frosts are lighter on slopes than on a valley floor.

Further information on frost occurrence may be found in Table VII. Here, for a few locations, are given the two average dates from which the frost-free seasons shown in Fig. 4 are calculated. These are averages; in a number of years spring frosts will occur later than shown and fall frosts earlier. The second half of the table shows, for instance, that one year in four a spring frost has occurred as late as June 13 (9 days after the average) at Melfort, and one year in ten as late as June 20 (16 days). These departures from average dates apply equally to fall frosts, and may be used to estimate risks of both late-spring or early-fall frosts at other points in the province.

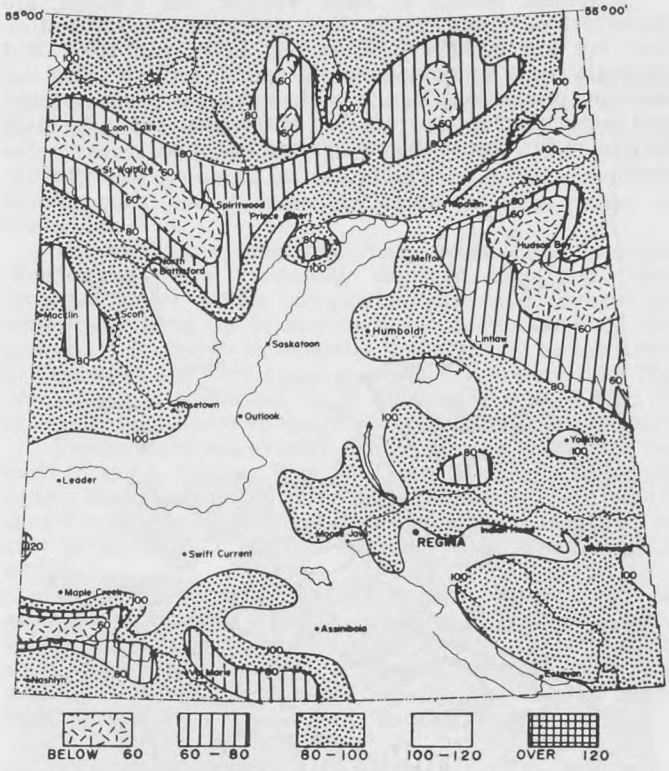


Fig. 4—Average annual frost-free period (days)

Note: Length of period in which the temperature does not fall below 32°F.

Frost Control—The following may be used to protect against frost damage:

1. Heed frost warnings on radio and television; 2. use recommended varieties; 3. avoid placing gardens in low areas and frost pockets, and avoid cultivation practices which may favor occurrence; 4. use cover materials. (Many plastics are useful only with a heater, since they are relatively transparent to heat radiation.); 5. undertake timely swathing of crops; 6. fill irrigation furrows with water, or use sprinkler irrigation. (Sprinklers are more effective than furrow irrigation, but create other problems such as damage from ice accumulation.); 7. follow phosphate fertilizer recommendation and proper seeding practices to ensure maximum seedling vigor.

Since the areas affected by frosts are highly variable, forecasts or warnings cannot cover all possibilities; the general area forecasts must therefore be interpreted in terms of your own farm.

Drought

Drought is generally defined as a period of dry weather of sufficient length and severity to cause at least a partial crop failure. While drought is common to most parts of the world, it is perhaps most critical in semi-arid regions like the Prairies. It may result not only in partial or total crop failure, but also in reduced fodder for livestock, water shortages, poor water quality, excessive heat, and wind erosion of the soil. It also causes loss of wildlife and appears to promote an increase in the grasshopper population. Droughts are most frequent and their effects most apparent in the drier southwestern part of the province.

TABLE VII

Average Dates of Last Spring and First Fall Frosts with Probability of Frosts Occurring Later or Earlier than These Dates

Location	Average date of last spring frost	Average date of first fall frost	Risks of frosts occurring later than average spring date or earlier than average fall date at all locations.	
			Probability	*Days from Mean*
Melfort	June 4	Sept. 8	33% or 1 year in 3	6
Outlook	May 20	Sept. 15		
Regina	June 1	Sept. 10	25% or 1 year in 4	9
Saskatoon	May 24	Sept. 15	10% or 1 year in 10	16
Swift Current	May 27	Sept. 13		

Drought has been recognized as a feature of the Prairie climate since the days when Capt. J. Palliser investigated the potential of the area for settlement. Repeated exposure to drought has led to improved soil and moisture conservation. This is particularly true of the period following the drought of the 1930s. Although the effectiveness of these procedures is not fully established, it is interesting to note that in 1961 Saskatchewan experienced intense drought without catastrophic effects. Table VIII compares precipitation for 1961 and the 1930s in Regina. Perhaps the real test lies in a sequence of dry years similar to those of 1936 and 1937, a situation indicated by the 1968 yields following a dry 1967. Table VIII also perhaps better demonstrates the excellent water-retention capacity of the Regina clay soils. (See yield difference between fallow and stubble.)

TABLE VIII

Regina Precipitation and Yield in Drought Years
In. of Precipitation

	MONTH							YIELD (bu/ac)	
Year	April	May	June	July	Aug.	Sept.	Total	Fallow	Stubble
1929	0.19	1.22	1.93	0.27	0.21	1.23	5.05	Not available	
1936	0.05	1.94	2.88	0.56	0.62	0.48	6.53	22.6	13.0
1937	0.04	1.24	1.02	1.10	0.68	0.77	4.85	7.2	0.3
1961	0.51	2.25	0.54	0.97	0.07	0.51	4.75	18.8	2.7
1967	0.17	0.29	1.15	0.19	0.69	3.34	5.83	31.3	18.1
1968	0.01	1.18	0.54	1.14	4.41	1.28	7.56	19.6	12.0
		Long-term average (37 years)—					11.0	23.3	17.5

Droughts can be both regional and local. Much of our summer rainfall comes from thunderstorms, which may repeatedly miss a certain area. When this happens a community may experience drought when its neighbors have ample or possibly excessive moisture. Regional drought occurs when large-scale atmospheric systems maintain a dry circulation over the region for extended periods. This type of drought affects more people and may cripple regional supplies. It is therefore of greater economic importance.

When drought conditions prevail, there is great danger of fire. Burning should be conducted with great caution. Particular hazard exists to swathed grain.

Drought Control—The impact of drought can be minimized by changing the use of unsuitable lands, breeding drought-resistant crop varieties, and practising soil and moisture conservation. Managing the snowpack to obtain maximum catch and infiltration is one way of practising conservation. Managing lands to reduce evaporation loss and increase infiltration during periods of excess moisture is another.

Serious drought usually results from two or more consecutive dry years, which deplete supplies of surface and soil moisture fairly completely. There is therefore time to reduce risks by taking such action as avoiding the buildup of excessive livestock herds, ensuring adequate water supplies after the first year of drought, and conserving soil moisture through snowpack management and other prescribed operations.

Severe Storms

Storms provide precipitation which is needed for crops and water supplies; however, they may also cause loss of life, property, and time. They vary in size and severity. Some affect the whole province; others affect only a few square miles.

Untimely storms delay seeding, cultivation, and harvesting. Blizzards and snowstorms may completely disrupt large areas of the province, and occasionally result in loss of both human life and livestock. Storm warnings may therefore be of great value in planning farm operations and avoiding serious loss of life or property. Heed weather forecasts and "Weather Warnings" which are given over radio and television when storms are expected that may endanger welfare, lives, and property!

Thunderstorm damage results mainly from hail, wind, and intense rain, but also occasionally from lightning. A thunderstorm moves in a path directed by the upper winds, not by those near the ground. Thunderstorms are more intense and frequent over hills than in valleys. They occur with greatest frequency in the southeastern part of the province. July is the month of peak activity, with thunderstorms occurring, on the average, on about 7 days during this month.

Hail

Hail is commonly associated with vigorous thunderstorms. Damage varies with both the intensity and the size of the hailstones, which have been reported occasionally as large as baseballs or teacups. Very large stones tend to be widely spaced and may not seriously damage a crop, but they can cause serious physical damage to livestock and buildings. Hailstorms that seriously damage crops average about 3 miles in width and 10 miles in length. However, on occasion new storm cells reform continuously so that the damaged area may stretch out over 200 or 300 miles. This can be catastrophic; a single storm in Saskatchewan in July, 1957, caused about $17,000,000 damage. The average annual hail loss in Saskatchewan is about 4 percent of the provincial crop.

Hailstorms appear to favor certain areas, as paths are possibly related to both topography and the general climate of the area. The relative frequency of hailstorms is indicated by insurance rates, which are shown in generalized form in Fig. 5. The effects of hail are most serious in the dry lands to the southwest and least serious in the Parkbelt.

Hail Suppression—Methods of reducing hail damage are being investigated. If the way in which hail forms were better understood it might be possible to alter the process and reduce losses. This problem has been under study in the Hailbelt near Red Deer, Alberta, over the past 10 years, as well as in other hail areas of the world. Results as yet are inconclusive.

Lightning

Lightning is an electric spark of phenomenal proportions. It often shatters non-conductors and it may burn or vaporize conductors. It will usually pass along bars of copper about the diameter of a pencil, but it may jump if it finds a better path. The best protection is given by metal-frame buildings; cars also give good protection provided the occupants stay completely inside. Isolated trees, wire fences, hilltops, and wide-open spaces should be avoided, as should the unnecessary handling of telephones, televisions, radios, and other electrical conductors. Stay away from chimneys, and avoid swimming or boating during electrical storms.

Excessive Rainfall

Whether or not rainfall is excessive often depends on the farm operation. Rains which are excessive during planting and harvest may be quite acceptable in the growing season. Excessive rainfall may be of the thunderstorm type, where the rates of fall are great; or it may result from prolonged, steady rains, which do little physical damage, but interfere with farm operations, and perhaps favor plant diseases such as rust.

Rainstorms of remarkable intensity have occurred in Saskatchewan. Over 10 inches of rain fell within 1 hour at Buffalo Gap in May, 1961, causing flooding and very serious soil erosion. Several rainstorms with intensities of 5 inches or more in 24 hours are usually reported annually. Soil conservation is necessary in hilly or rolling terrain to prevent excessive damage from these events. (See Agricultural Engineering section, "Erosion Control.")

Extensive periods of rainy weather, like drought, are characteristic of our climate. They delay seeding and cultivation, but are perhaps most critical in harvest time. Wet intervals cause depressions to fill with water and to be lost for crop production. More rapidly maturing plant varieties and mechanization are reducing operational risks; drainage may solve flooding problems in some instances.

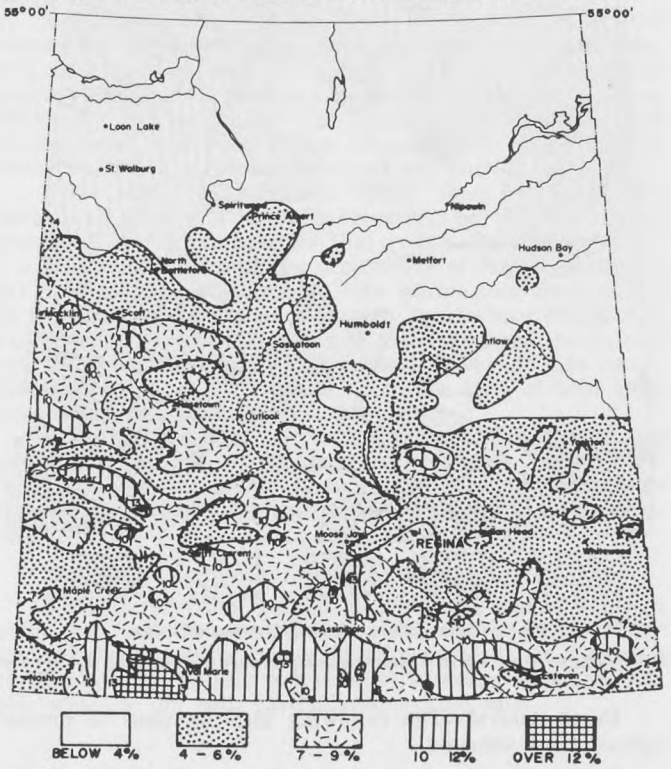


Fig. 5—Basic hail insurance rates (percent)
(Higher values indicate greater chances of hail)

Wind

Wind may physically damage crops and buildings. In hot weather, by its drying action, it may damage plants. It wastes water supplies and causes drifting. Once commonly used for power generation, it no longer competes with thermal- and hydro-power.

The general wind pattern is created by weather systems which cross the province. These systems have favored paths so that some areas may, in the long run, have winds fairly different from others. Topography also influences winds, resulting in such local differences as the high frequency of strong westerly winds north of the Cypress Hills. Within the broad-scale weather framework, small-scale weather systems such as dust devils, thunderstorms, and tornadoes account for most of the extreme winds during the growing season. Annually, gusts of about 100 mph are estimated to occur in wind storms over the province. Tornado winds have been measured (in Texas) at 280 mph, and have been estimated from structural damage to be as high as 675 mph.

Winds are greatly influenced by obstacles like large buildings and trees. This is apparent in the general wind field, which is much lighter in the Parkland than in the open prairie. (See Table IX.)

TABLE IX

Average and Extreme Hourly Wind Speed (MPH)

	JANUARY		JULY	
Location	Average	Extreme	Average	Extreme
Moose Jaw	15	58	12	50
North Battleford	9	35	9	40
Prince Albert	6	41	7	39
Regina	14	58	12	50
Saskatoon	12	46	11	39
Swift Current	16	60	15	56

Wind Control—Local winds may be reduced by shelterbelts and by special fencing. Shelterbelts reduce airflow downwind for a distance of at least 10 times their height, the effectiveness varying with the distance and the type of shelter. They are useful in preventing snow drifting, reducing heating costs, and in combating other problems caused by the wind.

The wind is of great importance when spraying crops. Weed sprays have frequently damaged trees and other sensitive plants within one-quarter mile, and under very windy conditions up to several miles downwind from the sprayer. It is, therefore, essential that spraying be restricted to days when the wind speed and direction are suitable. The ideal range is considered to be between 5 and 10 mph. It is usually inadvisable to spray when winds are over 15 mph.

Temperature and rainfall should also be considered for best spraying results. Rain too soon after spraying may reduce the effectiveness of the spray. Generally, weed killers should not be applied unless the temperature is expected to rise to about 60°F during the day. (See Weed Control section.)

Wind and weather information and forecasts may be obtained by phoning weather offices at Regina, Saskatoon, Prince Albert, and Moose Jaw. Limited information is available from Department of Transport weather observing stations at Broadview, Estevan, Hudson Bay, Meadow Lake, North Battleford, Swift Current, Yorkton, and Wynyard.

Tornadoes

Tornadoes occur throughout the Prairies, and have been reported as far north as Yellowknife, NWT. Most common in July, they have occurred as early as April 16 at Watrous.

A tornado is a violent, rotary windstorm or vortex of air of restricted diameter. The vortex forms a cloud, which takes on the appearance of a black snake-like cone extending from the main cloud base to the ground. The storm usually causes remarkable devastation throughout its path, which averages about 10 to 400 yards in width. The most destructive storm recorded on the Canadian Prairies was the 1912 Regina tornado, which caused $4,000,000 damage.

Knowing the characteristics of tornadoes may save lives. Most people killed in tornadoes are struck by flying debris—so take shelter! If caught in the open country, a ditch or a ravine offers some protection, but hold on to secure objects to keep from being blown away. If caught in a building, open doors and windows, turn off the electric power and gas, and do not panic. In frame buildings, the best shelter is in the basement in the corner from which the tornado is approaching—usually the southwest; when there is no basement, lie under heavy furniture which has been piled against an inside wall. Do not go into large, spacious areas or unreinforced buildings; culverts and ditches are preferable.

Dust Devils

Dust devils resemble miniature tornado funnels, but do not usually have significant destructive capacity. They are merely whirls of dirt, sand, and debris and have no associated cloud structure. They are caused by the ground being strongly heated, and therefore occur over dry ground on warm days, when there is relatively little wind.

WEATHER PROCESSES AND FORECASTS

Weather refers to warmth, wetness, storminess, and other meteorological conditions. These states are created by the combined influences of the sun, the earth, and the nature of the air which is present. Winter occurs when the sun is far to the south and little energy is received to heat the soil and the air. Summer occurs when the sun is high overhead and the days are long. Because different parts of the earth receive and absorb different amounts of energy, differences in air temperature occur from south to north, and from oceans to continents, prairie grass to snow fields. The presence of oceans, forests, deserts, and mountains causes the air to take on other properties relating to humidity, cloudiness, etc.

The earth's rotation and the effects of mountains, seas, and continents result in a continuous parade of atmospheric high- and low-pressure areas across the Prairies. These pressure systems control winds, shifting them at times northerly or southerly. Because of these winds, masses of colder and warmer air from regions to the north and south frequently are brought to the Prairies.

Clouds and precipitation on the Prairies often occur along fronts, which are the zones between the masses of warmer and colder air. The warmer air tends to rise in these zones, forming clouds and possibly precipitation. Clouds are usually thickest and rain heaviest along fronts in low-pressure areas. Fronts are referred to as warm, if warm air is advancing; cold, if cold air is advancing; or stationary, if there is little motion.

Air may be forced to rise when winds are blowing against a mountain. This may result in cloud and precipitation, as frequently occurs in the Cypress Hills area when winds are from the north.

Rising air currents also form when the ground and the air near the ground are strongly heated by the sun. When there is sufficient moisture present this may result in large thunderstorms. These storms are most common in early summer when the heating effect of the sun is near its peak.

Weather Forecasts

Weather forecasts may be used profitably in planning farm operations, and in the protection of life and property from weather extremes. Two types of forecasts are available: 1. Short-range forecasts which cover periods of up to several days, and 2. long-range forecasts which are usually monthly or seasonal.

Short-Range—Short-range forecasts are based mainly on the motions of high- and low-pressure areas and their related fronts or weather systems. The effects of topography and the sun are also taken into account.

Considerable skill is possible in this type of prediction; and the forecasts are even more useful when their limitations noted below are understood.

1. Predictions are most accurate over short periods. The accuracy decreases rapidly with time and at present there is little value in making forecasts for longer than 3 days.
2. When the weather is relatively uniform over broad areas, prediction is easier. However, sharply defined bands of weather may sometimes exist or be predicted to cross a region. Present skills do not permit these to be forecast with the pinpoint precision most of us would like. Slight errors in prediction of this type of weather may result in a reasonable, overall forecast being seriously in error in some localities.
3. Forecasts must, of necessity, be generalized for a region, and often over a period of time. The user should interpret these regional values in terms of his particular locality, based on his own experience. For example, during a frosty period, valley temperatures will be lower than the average for the area.

Long-Range—Long-range weather forecasts are still in the experimental stage. These forecasts are ordinarily restricted to general statements such as above- or below-normal temperature and precipitation. An evaluation of United States Weather Bureau 30-day "Outlooks" indicated that, although accuracy varied widely, the forecasts showed some skill and this was greatest in summer. Temperature predictions were more skillful than those for precipitation, and this skill was best in predicting hot, dry weather, rather than in normal or wet conditions.

Weather Lore

"An evening grey and morning red
Will send the shepherd wet to bed."

Weather lore is based on both factual observation and superstition. The above statement tested for London, England, proved right seven times out of ten, and a red sunset heralded dry weather with the same frequency. Both pieces of lore also have a sound scientific base. Others appear to be clearly fiction, or have lost their usefulness by being applied to countries or areas for which they were never intended. Much of our rich heritage of lore comes from Europe, which has a wet climate; applying it to the dry Prairies is incorrect. On the other hand, some sayings are quite general in application. For example, over 2,000 years ago the Greeks recognized that haloes foretold rain; modern-day studies confirm this as generally a valid prediction.

Some of the lore based on animal and plant activity has been severely criticized in the past. Many of these sayings, however, are now gaining prestige. Many creatures are much more sensitive to slight changes in humidity or temperature than are humans, and their reactions may therefore aid us in predicting weather changes.

However, lore is usually based on what is best remembered rather than on what always happens. It should therefore be used with that reservation in mind.

Perhaps linked with lore are recurring events such as "Indian Summer" and the "Bonspiel Thaw." These do not always occur, but they happen with sufficient frequency to be accepted as more than the result of chance. Their timing suggests that they are closely related to the effect of the sun on the general circulation of air over the oceans and continents.

Weather Services

Weather services are the responsibility of the Meteorological Branch, Air Services, Canada Department of Transport. Forecasts and weather reports are provided to Saskatchewan through weather offices at Regina, Saskatoon, and Prince Albert. The Meteorological Branch has over 250 co-operative weather observers in the province. Reports received from these observers are analyzed and published by the Branch's Climatology Division. The climatological analyses and the data contained in this report are mainly from this source.

The Meteorological Branch publishes educational material for schools and other information of general interest. A list of its publications may be obtained by writing to the Director, Meteorological Branch, Canada Department of Transport, 315 Bloor Street West, Toronto 5, Ontario.

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Atmospheric Environment Service*
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Is Lightning Really Dangerous?
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Temperature, Precipitation, and Sunshine at Selected Stations in Canada.
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What You Can Do About the Weather.
*Available from 4905 Dufferin Street, Downsview, Ontario. A number of these publications are free, for others there is a modest charge of 5 to 25 cents.

Canada Department of Agriculture
Evaporation Measurements at CDA Research Stations. Publ. 1210.
Heat Units and Crop Growth. Publ. 1042.
Influence of Depth of Moist Soil at Seeding Time on Wheat Yields in Southwestern Saskatchewan. Publ. 1090.

Other
Making the Most of the Forecast. Available from Weather Office in Regina, Saskatoon, and Prince Albert.

AGRICULTURAL ENGINEERING

FARM POWER AND MACHINERY

TRACTORS

Factors to be considered in tractor selection are: Size, type of engine, initial cost, method of obtaining traction, type of hydraulic system, and accessories. The type of engine selected (L.P. gas, diesel, or gasoline) will also influence the cost of owning a tractor.

Size

The general trend is to high-horsepower tractors pulling larger machines to complete field work when conditions are ideal, and reduce or eliminate extra labor requirements.

Large tractors are costly, and are uneconomical to operate under light loads, which may constitute a considerable portion of the farm operations.

Tractor and implement size should be matched so that under normal operating conditions, at desirable field speeds, approximately 75 percent of the maximum drawbar horsepower is being utilized.

Refer to tables on page 14 for horsepower requirements for tillage and seeding machines. (See reference 1.)

Selection and Operating Costs

Tractor costs may be divided into two main types: 1. Fixed costs, and 2. operating costs. Fixed costs include depreciation, interest on investment, insurance, and housing. These costs represent a fixed annual charge. The cost per hour of operating decreases with increased hours of use per year. In most instances, the fixed cost of the tractor will be a relatively large portion of the total cost, perhaps as much as three-quarters.

Operating costs are those that occur only when the tractor is actually in use, as, for example, fuel, lubrication, and repair costs. Hourly operating costs are constant regardless of the number of hours of use per year. (See reference 2.)

Tractor fuel costs may be estimated from the following formula:

$$\text{Cost/hr (dollars)} = \frac{\text{Fuel cost, (cents/gal) x max. P.T.O. hp}}{A}$$

where A = 2400 for diesel
= 1750 for gasoline
= 1460 for L.P. gas

The above formula allows an additional 15 percent of the fuel cost for year-round operation, according to current practice of the American Society of Agricultural Engineers. The figure obtained will represent fuel cost for year-round operation, or, in other words, an average for light and heavy loads.

Example:

A diesel tractor has a drawbar horsepower of 95 and a maximum P.T.O. horsepower of 115. The cost of diesel fuel is 20 cents per gallon. The operating cost per hour is:

$$\frac{20 \times 115}{2400} = \$0.96$$

Four-wheel drive tractors offer an advantage over two-wheel drive in soft, wet, or loose soils by increasing the drawbar pull for a given wheel slip. Other advantages of four-wheel drive are increased mobility and maneuverability, less tendency to "skew" on side hill operation, and less soil compaction.

Dual wheels may be added to each driving wheel of either two-wheel or four-wheel drive tractors. Dual wheels can be used to improve traction and decrease compaction in soft conditions, but cannot be expected to increase drawbar pull or reduce slippage appreciably for the same rear axle weight. Differential locks equalize traction when used under adverse conditions.

Traction efficiency is the percentage of maximum P.T.O. horsepower available as drawbar horsepower.

$$\text{Traction efficiency \%} = \frac{\text{Maximum drawbar hp x 100}}{\text{Maximum power takeoff hp}}$$

Comparative traction efficiencies (%) for various soils

Surface Conditions	2-wheel drive	4-wheel drive	Tracks
1. Soft, wet clay soils or loose, sandy loam soils	56	63	72
2. Soils intermediate in firmness between 1 and 3	60	66	78
3. Very firm, dry clay soils	67	72	75

Maximum power efficiencies are obtained using adequate wheel ballast at slippages near 15 percent for two-wheel drive tractors and near 10 percent for four-wheel drive tractors. (See reference 3.)

Hydraulic Systems

The hydraulic system may operate any or all of: Remote cylinders, power steering, power brakes, power-shift-type transmissions, hydrostatic motors, and attached implements.

Hydraulic pumps may be positive or variable-displacement types and may be driven at crankshaft or power takeoff speed.

Large-capacity pumps may be used and at full capacity may require up to 20 horsepower.

Control valves may be single or multiple units and may be either open- or closed-centre type depending on the type of hydraulic pump used. Maximum pump output may not be available at remote outlets.

Cleanliness is essential when servicing or attaching hydraulic equipment.

Transmission Types

Tractor transmissions may be selective sliding gear, syncromesh, power shift, or hydrostatic types, with a variety of methods for on-the-go shifting.

Planetary-gear-type transmissions provide for up- or down-shifting without stopping forward travel.

Hydrostatic-type transmissions consist of an engine-driven hydraulic pump which pressurizes oil to operate a hydrostatic motor connected to the driving wheels. An infinite range of forward speeds is obtainable.

Tires

Tire size should match the horsepower developed by the tractor.

The drawbar pull that a tire can transmit depends primarily on the weight it carries. Tires must not be weighted with calcium chloride, dry ballast, or wheel weights beyond the manufacturers' recommendations. Dry ballast is more expensive than calcium chloride and overheating may occur with continuous use at high speeds. Tire pressure should always be sufficient to prevent damage from sidewall flexing. Front tires may need weights to improve steering and to reduce lifting of the front end. Agricultural tires are not designed for speeds over 20 mph.

The capacity of a front-mounted bucket or fork must not be larger than the rated carrying capacity of the axles and tires. Light-model loaders are not generally suitable for rock handling or earthwork. Allowable weight limits on tires and axles should determine the selection of snow plows and similar front-end attachments.

Turbochargers

Exhaust-driven turbochargers on farm tractors increase the horsepower output by increasing the amount of air entering the engine. Turbocharging kits for tractors are available but care should be exercised in their installation and use.

Engine modifications necessary are: A larger air cleaner and intake manifold, a larger radiator or increased cooling system capacity, and the addition of a lubricating oil cooler. Intercoolers are also used on some engines to reduce the temperature of the air passing through the intake manifold.

The recommended operating precautions should be exercised when using a turbocharged tractor. Operating precautions recommended when using a turbocharged tractor include: 1. Do not open throttle wide open immediately after starting; 2. allow engine to idle with no load for a few minutes before stopping; 3. reduce oil and filter change intervals.

L.P. Gas Injection

L.P. gas injection into agricultural diesel engines may be used. A research report on this topic has pointed out the following conclusion: maximum power is increased by the automatic injection of L.P. gas into the intake of a diesel engine when the engine load requirement reaches 60 percent of maximum.

Noise Level

Tractor noise originates from various sources, including exhaust, transmission and differential gear trains, hydraulic pump, cooling fan, and other moving parts.

These noises combine to create a sound level in most tractors high enough to be objectionable or injurious to the operator. Tractor and tractor cab manufacturers are conducting research to reduce noises to an acceptable and non-injurious level. Noise having a sound level of over 90 decibels for a sustained period of time will cause hearing loss to the operator.

Tractors tested at Nebraska for horsepower ratings are now being measured for noise levels. Results will be included in future Nebraska test report bulletins.

Liquid-filled ear muffs are effective in reducing noise to an acceptable level. Ear plugs are not as effective as ear muffs.

A well-designed, correctly mounted, insulated cab will reduce noise level considerably and add greatly to operator comfort. Cabs which are particularly noisy may be improved by lining them with an effective sound-deadening material and by the addition of a layer of insulating material as a mat on the floor. Rubber washers or pads at the points of attachment of the cab to the tractor frame are also helpful.

Roll Bars

Roll bars for operator safety are now available from all major tractor manufacturers. Some companies are incorporating them into cabs as standard equipment.

Fuel Storage

Tractor fuels are generally stored in bulk tanks high enough above the ground so tractors may be refuelled by gravity flow through a hose. Steel stands are recommended for durability and strength. Tanks should be raised a few inches at the fuel outlet end so that rust, dirt, and water may be periodically drained off.

Storage tanks should be grounded to a metal rod driven in the ground to reduce fire hazard. Tractors should also be grounded when being refuelled. Storage tanks should be a minimum of 50 feet from the nearest building. Evaporation losses from gasoline storage tanks may be reduced by using a relief valve type vent cap, painting the tank a light color, or building a sun shield above the tank.

Clean diesel fuel is very important for trouble-free operation. It should be allowed to settle at least **1 day** after the storage tank is filled. Service diesel fuel filters carefully, following instructions given in the operators' manual.

Servicing Dry-Type Air Cleaners

Various methods are recommended for cleaning dry-type air filter elements; these include using compressed air and washing with a detergent solution. It is essential the recommended cleaning instructions printed on the cleaner or in the operators' manual be carefully followed.

REFERENCES

1. *Tractor Selection and Nebraska Tests.* Publ. 240. Extension Division, University of Saskatchewan, Saskatoon.
2. *Agricultural Machinery Costs.* Publ. 1291. Canada Department of Agriculture.
3. 1969 *Traction Test Bulletin.* Manitoba Department of Agriculture, Extension Services Branch, Agricultural Engineering Division.

OILS

Lubricating Oils

Straight mineral oil contains no additives, whereas compounded oils contain varying amounts and kinds of additives depending on the service requirements of the oil. Compounded oils are available in standard or multi-viscosity SAE grades. Recommended oil change periods should be closely followed to reduce the possibility of viscosity change due to extended oil change intervals. Adverse operating conditions such as winter driving may require more frequent than recommended oil changes.

Multi-viscosity oils (e.g., SAE 5W-20) were developed primarily for climates where temperatures vary widely. They provide adequate lubrication during cold starts and high temperature operation. They are called "multi-viscosity" oils because they are thin enough at low temperature to meet the requirements of a low viscosity number and thick enough at high temperature to meet the requirements of a higher number as shown in Fig. 1.

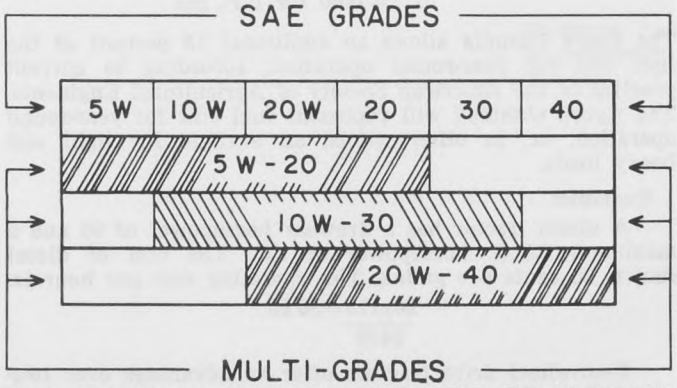

Fig. 1—Multi-viscosity grades (e.g., 5W-20, 10W-30, 20W-40) meet the specifications for several single grades (e.g., 5W, 10W, 20W, etc.) and therefore can be used over a wide range of temperatures.

Service Classification—A new system of service classification for engine lubricating oil has been established through the co-operation of the American Petroleum Institute (A.P.I.), American Society of Testing Materials (A.S.T.M.), and the Society of Automotive Engineers (S.A.E.). The new classification replaces the A.P.I. designations ML, MM, MS, and DG, DM, and DS.

The "open-end" service classification uses a two-letter system; the first letter classifies the oil as to service station oil "S" or commercial, farm, or industrial oils "C" and the second letter designates oil quality.

Descriptions of Service Classifications—The following descriptions may be used as a guide for selecting the proper engine oil for different service conditions.

The service classification letters are clearly printed or stamped on oil containers.

"S" Service Station Oil: Available at Service Stations, Garages, New Car Dealers, etc.

SA (ML)—For Utility Gasoline and Diesel Engine Service*

Service typical of engines operating under conditions that do not require the protection afforded by compounded oils. This classification has no performance requirements and is a straight mineral oil.

SB (MM)—For Minimum-Duty Gasoline Engine Service*

Service typical of gasoline engines operating under conditions that require only minimum protection afforded by compounding. Oils designated for this service have been used since the 1930s and provide only anti-scuff capability, and resistance to oil oxidation and bearing corrosion.

SC (MS 1964)—For 1964 Gasoline Engine Warranty Maintenance Service*

Service typical of gasoline engines in 1964 through 1967 models of passenger cars and some trucks operating under engine manufacturers' warranties in effect during those model years. Oils designed for this service provide control of high- and low-temperature deposits, wear, rust, and corrosion in gasoline engines.

SD (MS 1968)—For 1968 Gasoline Engine Warranty Maintenance Service*

Service typical of gasoline engines in 1968 through 1970 models of passenger cars and some trucks operating under engine manufacturers' warranties in effect during those model years. Also may apply to certain 1971 and/or later models as specified (or recommended) in the owners' manual. Oils designed for this service provide more protection against high- and low-temperature engine deposits, wear, rust, and corrosion than SC oils, but may be used where SC oils are recommended.

SE—For 1972 Gasoline Engine Warranty Maintenance Service

Service typical of gasoline engines in passenger cars and some trucks beginning with 1972 and certain 1971 models operating under engine manufacturers' warranties. This oil provides more protection against oxidation, high temperatures, engine deposits, rust, and corrosion in gasoline engines than SD and SC oils, but may be used when either SD or SC is recommended.

"C" Commercial: Available at Bulk Sales Outlets for Contractors, Farmers, etc.

CA (DG)—For Light-Duty Diesel Engine Service*

Service typical of diesel engines operating under conditions of mild to moderate duty with high-quality fuels, but occasionally has included gasoline engines in mild service. This oil provides protection from bearing corrosion and from high-temperature deposits in normally aspirated diesel engines using fuels of such quality that they impose no unusual requirements for wear and deposit protection. They were widely used in the late 1940s and 1950s.

CB (DM)—For Moderate Diesel Engine Service*

Service typical of diesel engines operated under conditions of mild to moderate duty, but with lower quality fuels which necessitate more protection from wear and deposits. Occasionally, has included gasoline engines in mild service. Oils designed for this service provide necessary protection from bearing corrosion and from high-temperature deposits in normally aspirated diesel engines with higher sulfur fuels. Oils designed for this service were introduced in 1949.

CC (DM)—For Moderate-Duty Diesel and Gasoline Engine Service*

Service typical of lightly supercharged diesel engines operating in moderate to severe duty, and certain heavy-duty gasoline engines. Oils designed for this service provide protection from high-temperature deposits in lightly supercharged diesels and also from rust, corrosion, and low temperature deposits in gasoline engines. These oils were introduced in 1961 and are used in many trucks and in industrial construction equipment and farm tractors.

CD (DS)—For Severe-Duty Diesel Engine Service*

Service typical of supercharged diesel engines in high-speed, high-output duty requiring highly effective control of wear and deposits. Oils designated for this service were introduced in 1955 and provide protection from bearing corrosion and from high-temperature deposits in supercharged diesel engines when using fuels of a wide quality range.

Use of Letter Designation

Oil manufacturers indicate on the container the type of service for which the oil is intended or required (e.g., A.P.I. Service SD). If oils are suitable for more than one type of service they will be so designated on the container (e.g., A.P.I. Service CC and SE).

Lubricating Oil Use—1. Change oil and filters as recommended by the engine manufacturers; 2. keep oil in the container protected from contamination by dirt and water; 3. the best assurance of satisfactory performance is to purchase oil from a responsible supplier. Oils with the same rating may differ widely; one manufacturer may just meet the minimum requirement, while another will exceed it; 4. use oil of the service classification and viscosity recommended by the engine manufacturer; 5. use SD oils in gasoline and L.P. gas engines, giving preference to oils which have passed a manufacturer's sequence test; 6. do not mix oils of different specifications such as SB and SD; 7. remember that trying to save money on oil may cost more in the long run.

Hydraulic Oils

There are two types of hydraulic oil:

1. Oil used only by the hydraulic system and stored in a separate supply tank. Various types of oil may be used, such as straight mineral oil, mineral oil with additives, automatic transmission fluid or others depending on the system and the type of oil recommended by the manufacturer.
2. Combination transmission-hydraulic oil used as both gear and hydraulic oil and stored in the transmission case. The oil has special properties and additives as required by the tractor manufacturer. Tractor manufacturers warn against mixing other oils with this oil.

Cleanliness is essential in handling hydraulic oils, as dirt is the worst enemy of hydraulic systems. When adding or changing oil in a hydraulic system, use the same oil or one that is known to be compatible.

Hydraulics on Implements—Tractor hydraulic systems will raise, lower, or adjust mounted- and pull-type implements and operate hydraulic motors.

*Previous A.P.I. Service Designations.

Hydraulic systems may have single or multiple control valves to operate one or more remote cylinders independently.

A single control valve may be used to operate two or more remote cylinders simultaneously by using flow dividers or by coupling in series. Cleanliness of the oil is of prime importance because of the precision fit of pumps, valves, and pistons. A heavy-duty oil of SAE 10 or 20 viscosity should give satisfactory service. To safeguard the warranty, manufacturers' specifications as to type of hydraulic oil should be strictly followed.

On some of the larger tractors, up to 20 horsepower may be required to operate the hydraulic system at maximum pressure. Hydraulic motors can be applied to mower drives, conveyors, grain augers, and other equipment. Advantages include: 1. Variable speeds; 2. rapid means of reversing rotation; 3. elimination of gear trains; 4. can be stalled without damage.

The horsepower delivered from a pump to a motor:

$$\text{Pump hp} = \frac{\text{gpm} \times \text{psi}}{1430}$$

where "gpm" = Imperial gallons per minute and "psi" = pounds per square inch pressure.

Horsepower output from a motor:

Motor hp =
pump hp x motor efficiency*

Speed of hydraulic motor from displacement and flow rate:

$$\text{gpm} \times \frac{1}{\text{displacement}} \times 277 = \text{rpm}$$

where displacement = cubic inches per revolution.

Example:

Given—hydraulic system with relief valve setting of 1,500 psi. Pump delivers 12 gpm. Hydraulic motor has an efficiency of 80 percent and a displacement of 6.2 cubic inches per revolution.

Find:

1. The maximum horsepower output from the hydraulic motor.
2. The motor speed, rpm

Solution: $\text{Pump hp} = \frac{12 \times 1500}{1430} = 12.6$

$\text{Motor hp} = 12.6 \times 0.8 = 10.1$

$\text{and speed} = \frac{12 \times 277}{6.2} = 536 \text{ rpm}$

*Motor efficiency supplied by manufacturer.

TILLAGE AND SEEDING MACHINERY

Discers

Discers provide rapid and economical shallow one-way disc tillage and a reasonably efficient once-over combination tillage-seeding method.

Satisfactory and stable operation of a discer depends on proper hitch adjustment. A narrower width of cut (greater disc angle) improves weed kill at shallower depths required for seeding and permits better penetration in hard soils. Shallow-concavity discs clear more satisfactorily, particularly in heavy soils. The smaller diameter discs penetrate better, but need to be replaced sooner.

Discers destroy about 50 percent of the trash cover on each operation. Higher speeds may pulverize soil and reduce penetration. Less trash is anchored and the machine loses stability.

Machine widths of not more than 12 feet either in single or multiple units provide more uniform tillage.

Satisfactory seeding with discers requires proper location of seed spouts and control of tillage depth. Spouts have to be located closely behind each disc to drop seed to the bottom of the furrow. A narrower width of cut will permit shallow seeding with better depth control, weed kill, and narrower row spacing. Narrow row spacing is an advantage in areas where windrowing is practised.

Grain feed-shaft turning monitors and depth indicators will assist in avoiding poor seed placement, poor germination, and emergence.

Special attachments such as feed-shaft speed reducers are available for more accurate calibration and seeding of small seeded crops such as rapeseed and mustard seed.

TABLE I
Tillage Machinery—Power Requirements

Machine	Recommended (Maximum) Depth (in.)	Recommended (Maximum) Speed (mph)	Average Tractor Hp/ft Width*
Discer	3	5.0	3.5
One-way	4	4.0	4.0
Blade	3	5.0	3.75
Cultivator, heavy duty	3	5.0	3.25
Cultivator, heavy duty with rod weeder attachment	3	5.0	4.75
Harrows	N/A	5.0	0.75
Plow	4.5	4.0	6.0
Rod weeder	2.5	5.0	1.75

*Average tractor hp/ft width takes into account such factors as tractor slippage, rolling resistance, steep slopes, etc. The figures given are suitable for determining tractor size in terms of maximum dbhp or the machine width where the maximum dbhp is known, e.g., a discer requires 3.5 hp/ft width at 5 mph; a 15-ft discer will require a tractor with a maximum of 52.

TABLE II
Seeding Machinery—Power Requirements

Machinery	Recommended Speed (Maximum)	Hp/ft Width
Double-disc drill	5.0	1.5
Hoe press drill	5.0	2.5
Double-disc press drill	5.0	2.2
Cultivator with seeding attachment	4.0	3.5
Rod weeder seeder	5.0	3.7
Packers	5.0	1.5

TABLE III
Custom Rates

Machine	Custom Charge per ac Low	High	Average
Discer	1.00	1.50	1.25
Discer seeding and fertilizer attachment	1.00	2.00	1.50
Press drill and fertilizer attachment	1.00	2.50	1.65
Harrows	.25	.50	.40
Heavy-duty cultivator	1.00	2.50	1.75
Field cultivator	.75	1.25	1.10
Rod weeder	.50	1.25	.90
Sprayer (not including chemical)	.45	.55	.50
*Mower and rake	1.00	2.50	1.75
Pull swather	.75	1.50	1.25
**S.P. swather	1.00	2.00	1.50
Baler (plus twine)	.07/bale	.12/bale	.09/bale
***S.P. combine and straw chopper	3.25	6.50	4.40

Grain Trucking
Field to storage: 50c per ac
Farm to market: 3c per bu first 5 miles,
+3c to 5c per bu each additional mile.

*Mowing would be approximately double the rate for raking.
**Swathing charges for hay 25 to 50 cents higher.
***Straw chopper 25 to 50 cents per ac.

The above rates include tractor, tractor expenses, and operator.

Factors to consider in estimating a fair custom rate include: type of soil, hardness of soil, topography, presence of stones, weather conditions, kind and condition of crop, and yield per acre. Where adverse operating conditions prevail because of any of the above factors, the rate per acre would be proportionately higher.

Land packers are essential when seeding with discers. Flexible types work better on heavier soils, due to self-cleaning.

Cultivators

Heavy-duty cultivators can penetrate deeper into the soil than discers but generally some ridging results. More trash is buried at higher field speeds but less is buried than with discers.

A cultivator must be adjusted so that when in operation the frame is level both in the direction of travel and at right angles to the direction of travel. To ensure weed kill, sweeps must overlap; where row spacing is 2 to 2½ feet, an overlap of 4 inches is considered adequate. Machine widths of more than 12 feet, either in single, wing type, or multiple units, provide more uniform tillage. Good trash clearance depends on shank and row spacing as well as vertical clearance.

Shanks positioned about 30 inches from each other give good trash clearance. Some light field cultivators do not provide this spacing and lack trash clearance. The vibrating shank cultivator generally will not penetrate as deeply as the heavy-duty type and is not intended to replace it. Satisfactory cultivation is obtained in secondary tillage operations and in first operations where the soil is not so hard that penetration is a problem. Clearance may not be adequate in heavy trash.

Seeding attachments for cultivators have not performed as well as other seeding equipment because of the lack of depth control and wide row spacing.

Blades

A blade is the best machine for conservation of surface trash cover in the drier areas of the province. Trash clearance is better than cultivators and the field surface remains more level. About 85 percent of the trash is maintained in an upright position. Blades do not perform well in clay soils or when soils are very wet. Blades must be level at operating depths to function properly. Weighting is usually necessary for satisfactory penetration.

Rod Weeders

The rod weeder is a light draft, secondary tillage machine which gives good weed control under dry conditions. It preserves trash cover but tends to pulverize surface clods when operated at a shallow depth. Power–takeoff–driven models give the machine better penetration. Proper vertical hitch adjustment is necessary for good rod penetration.

Double-Disc Drills and Press Drills

These machines seed satisfactorily into previously tilled soil where trash is not excessive. Depth of seeding depends largely on depth of previous tillage. High-speed operation over 5 mph may cause poor seed placement.

Single-Disc Drills

Single-disc drills are similar in construction to double-disc ones, with the exception of the furrow openers. In the single-disc drill, each furrow opener consists of a single concave disc set at a slight angle to the direction of travel; the disc moves the soil to one side as the furrow is opened.

Penetration is most satisfactory in previously tilled soil and where trash is not excessive. Single-disc openers generally cut through trash and penetrate better than double-disc openers and do not clog as easily.

Packing or levelling with harrows after seeding improves germination and emergence of the crop.

Packers

Packing is advantageous, particularly after seeding, to compact the soil to reduce evaporation and promote rapid and uniform germination of the seed.

Flexible sub-surface packers are effective after disc machines, as they are less likely to plug in wet and clay-type soils.

To be most effective, packers should weigh 100 pounds per foot of width.

Surface-type packers with flat-faced wheels pulverize excessively.

Fertilizer Applicators

Attachments for seeders: These units have a variety of metering mechanisms and will normally handle dry fertilizer. High humidity can cause problems and may affect the delivery rate, particularly with blended fertilizers such as 23-23-0 or 27-14-0. The attachment must be capable of delivering the maximum number of pounds per acre at the highest recommended seeding speed so as not to limit the seeding rate. The rate of delivery should be easy to set and the box large enough so that it does not become empty before the grain seed box.

Size of box required (lb/ft)=

$$\frac{\text{Grain box size (bu/ft) x rate of fertilizer applied (lb/ac)}}{\text{Seeding rate (bus/ac)}}$$

The box should be weatherproof and corrosion resistant. Boxes must be cleaned after use to prevent corrosion of metal parts. Washing with ample quantities of water is usually satisfactory.

Broadcast Spreaders

The spreading of nitrogen fertilizer at high rates requires the use of broadcast spreaders. To obtain satisfactory and uniform application, the spreader must spread the fertilizer uniformly. Adjustment of the spreader is important and may have to be changed for different kinds of fertilizer. It is very important to drive the correct distance from the previous round so that the correct amount of overlap is obtained. Poor machine performance and incorrect overlap can result in uneven application, with resultant stripping or uneven growth. The broadcast spreader is, however, a convenient and quick method of applying fertilizer. Widths of 30 to 50 feet are covered on each round at rates up to 500 or more pounds per acre.

Liquid Fertilizers

Fertilizers can also be applied in liquid form using the proper equipment. The use of this method is not widespread but it is expected that it will be used more in the future.

Refer to Equipment for Applying Agricultural Chemicals, page 23.

REFERENCES

Farm Sprayers. Publ. 1157. Canada Department of Agriculture.
Weed Sprayer Operation (Saskatchewan Advisory Weed Council). Saskatchewan Department of Agriculture.

HARVESTING MACHINERY

Swathers

Swathers permit earlier cutting of grain, thus reducing losses from insects, hail, and frost and reducing problems with green undergrowth. Cutting height should seldom exceed 8 inches.

Self-propelled swathers have an advantage in opening fields and in cutting around bluffs and sloughs, but they usually cost more than twice as much to buy as pull types. The self-propelled swather is useful, too, for cutting lodged or tangled crops. When swathing a crop from one side of the field only, time and distance for hauling grain from

the combine may be reduced. Some centre and end delivery swathers may be adapted for double-swathing attachments.

Reel speed should be adjusted to forward travel. A general guide for a reel 50 to 56 inches in diameter is 35 to 40 rpm at a forward speed of 5 mph.

Double-swath attachments may be used to lay one swath on another or two swaths side by side. One swath on another in light crops usually reduces pickup losses by one-half. Double swaths reduce combining time and make better use of combine capacity in light crops, but a straw chopper on the combine may be necessary to cut and spread the straw that could interfere with subsequent tillage and seeding operations. Offsetting double or single swaths in alternate cropping years would provide more even distribution of combined straw on the field surface.

Pickup reels assist in lifting lodged crops for easier cutting. Extended and modified divider boards for the outside end of the table prevent plugging in tangled crops, and crops such as rapeseed, flax, and mustard. A swath roller behind the swather assists in anchoring bulky swaths into the stubble to prevent them from being blown away by the wind.

Four general types of swaths are shown in Fig. 2. Some swaths are a combination of two or more types. End-delivery swathers may produce a parallel or angled parallel swaths. Centre-delivery swathers may produce fantail, herringbone, or parallel types. Platform angle and canvas speeds affect the type produced. Very steep table angles tend to make bunchy swaths.

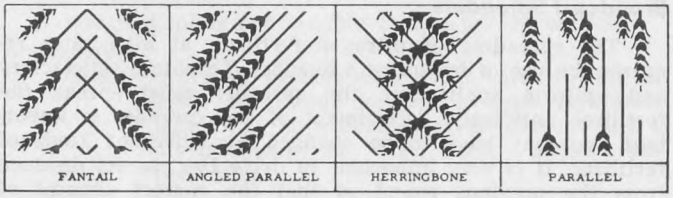

Fig. 2—Types of swaths

Fantail—Sometimes formed in tall, fluffy crops. Picks up easily. Grain is poorly protected.
Angled parallel—Stays up well on stubble and is easily picked up. If angle is too great, heads will settle to one side and butts will be tipped up by wind.
Herringbone—Easily picked up. The centre of the swath is sometimes heavy and settles, tipping up the butts. This swath then becomes subject to damage from wind, snow and rain.
Parallel—Settles into stubble readily and is difficult to pick up. Has good resistance to wind.

Combines

Power takeoff (PTO) driven combines require a tractor with adequate power to pull the combine and also operate it at maximum capacity without loss in cylinder speed. Correct PTO speed must be maintained to assure proper threshing and separation. A live power takeoff is recommended. Power takeoff and engine-driven pull-type combines require a tractor with a wide range of forward speeds, with the slowest speed near 1 mph. On-the-go shift-type transmission provides gear changes without stopping, and hydrostatic transmissions provide an infinite range of forward speeds while on the move.

The self-propelled combine has good field-opening ability and is readily maneuverable. Variable speed drives and hydrostatic transmissions provide on-the-go forward speed changes as required. Combine power requirements for normal conditions may be based on an index of 1.3 horsepower per inch of cylinder width.

Combine Operation

Field losses of grain at harvest have always been of concern to producers. The loss from wind, rain, hail, insects, animals, and birds increases rapidly as the grain matures. Loss of grain results from careless windrower and combine operation, as well as from natural causes. The reel and cutter bar loss, which applies to both the windrower and the combine, increases as grain is cut at successively later stages of maturity. The pickup loss also is large with grain windrowed at late stages. The combining losses can be severe, the major source being over the straw walkers. To reduce this loss is to slow down the forward speed of travel.

The following information will help reduce field losses.

1. Grain may be windrowed at a stage of maturity when the moisture content of the kernels is 35 percent for wheat, 40 percent for barley, 45 percent for fall rye, and 35 percent for oats. The kernels at this moisture content are in the late dough stage, quite firm, but may be dented by the thumb nail. (See "Harvesting" in Cropping Practices section, page 130.) 2. pickup losses increase rapidly at speeds greater than 4 mph; 3. straw walkers can be readily overloaded and it is at this point that major losses usually occur first in cereal crops. In many machines these losses begin well below the feed rate at which cylinder capacity or lack of power becomes a problem. To avoid walker losses, slow down. An increase in speed to 4 mph from 3 may increase losses to 3 bushels per acre from 1; 4. when the cylinder speed is changed, the speed of the remainder of the combine must be maintained for proper cleaning and to assure maximum capacity. For special crops the speed of the entire machine may be reduced when recommended; 5. the adjustment of one machine component may necessitate other adjustments.

Combine Adjustments

Problem	Cause	Remedy
White caps in grain tank.	Heads dry and brittle; chaff sticks to kernel.	Use concave blanks. Reduce size of lower sieve opening or use round-hole-type lower sieve.
Long straws in threshed grain.		Reduce chaffer opening, air flow, and forward speed all at the same time.
Threshed grain going over the straw walkers. (This is the major loss.)	Overloading straw walkers. Lack of separation of grain through the concave	Reduce forward speed if machine is overloaded. Increasing cylinder speed and decreasing concave clearance will increase separation at the concave; however under very dry conditions this could increase grain crackage and straw breakup, resulting in matting on the walkers. A compromise in adjustments is, therefore, required.
Whole and partial heads in tailings.	Poor cylinder threshing.	Increase cylinder speed. Decrease concave clearance. Install concave blanks.
Cracked grain in tailings.	Poor cylinder threshing. Grain too dry.	Reduce cylinder speed. Increase concave clearance.
Whole kernels in returns.	Over cleaning.	Open lower sieve.
Excessive chaff in returns.	Improper adjustment of machine.	Reduce chaffer opening. Increase air flow. Reduce cylinder speed.
Incompletely threshed heads.	Cylinder condition and/or adjustment.	Adjust cylinder clearance and speed. Replace worn or damaged cylinder and/or concave bars.
Excessive pickup losses.	Short straw, light windrows. Poorly formed windrows.	Operate pickup close to ground.

Monitoring devices may be installed on combines to indicate to the operator when parts such as augers and elevators become overloaded or plugged.

Monitors may be attached to straw walkers and/or chaffer to indicate losses. The operator may safely increase the forward travel of the combine until maximum capacity is reached. When overloading occurs it will be indicated by the monitor, and the operator should slow down. (See reference 1.)

Harvesting Special Crops

Malting Barley—To meet the requirement for malting barley the sample must be plump, mature, and contain a minimum percentage of cracked or skinned kernels.

Choosing the correct swathing time is critical to minimize the number of green, immature, and shrunken kernels.

When threshing, cylinder speed and concave clearance are important adjustments to prevent cracking or peeling kernels. Careful setting of the chaffer, cleaning sieve, and air blast is necessary to obtain an acceptable sample with the least amount of return to the cylinder.

After threshing, the grain should be handled a minimum number of times to prevent further cracking or kernel damage. (See reference 2.)

Flax—Flax may be straight-combined or swathed; however, if the crop ripens unevenly or contains weeds, swathing is recommended.

A roller may be used behind the swather to anchor the swath into the stubble to reduce wind damage.

A gentle-acting pickup turning at the correct rpm reduces shatter losses.

The same cylinder speed as for wheat is generally satisfactory. The concave clearance should be less than for wheat, as flax bolls are quite small. The use of concave blanks improves threshing and reduces the numbers of bolls in the return to the cylinder.

Flax is easily blown out over the chaffer sieve, and losses may be excessive if chaffer and air blast adjustments are not correct.

The cleaning sieve should only be open wide enough to give clean grain in the tank with a minimum amount in the return. (See reference 3.)

Rapeseed and Mustard Seed—These crops may be straight-combined; however, losses occur if they are left standing too long in the field. Mustard is more resistant to shattering and may be straight-combined if the field ripens evenly. Swathing is recommended, particularly if there is uneven ripening. It may not be economical to swath a light stand of either crop.

Once started, ripening advances rapidly, so if swathing is anticipated, the field should be closely watched to determine the proper time to start cutting.

Rapeseed swathing should start and be completed as quickly as possible when about 25 percent of the seeds have changed from green to brown but the pods may still be green. Rolling with a swath roller assists in anchoring the swaths.

Under normal conditions, the seeds mature in 5 to 10 days after swathing, and threshing should start as soon as the moisture content of the seeds reaches 10.5 percent.

Pickup speed should be set to pick up the swaths as gently as possible.

Cylinder speed may be reduced by one-third to one-half the speed used for wheat, and the concave clearance set so threshing is complete, with pods and stems not broken excessively to overload the chaffer. Chaffer overloading makes separation difficult.

Rapeseed and mustard seed blow out over the chaffer easily, so the fan speed should be reduced to two-thirds of normal speed and the fan shutters open to obtain the correct amount of air through the chaffer, which may be set one-quarter to one-third open.

The cleaning sieve should be closed as much as possible, yet allowing complete separation with no seeds being returned to the cylinder. (See references 4 and 5.)

Sunflowers—Sunflowers require a longer period to mature than cereal grains, and a crop seeded in early May is usually ready to harvest by mid-October.

Straight combining is the most practical method of harvesting sunflowers.

A moisture content of 12 percent or less is recommended at threshing time; however, for long-term storage a moisture content of 9.5 to 10 percent is desirable.

The reel and cutter bars of combines are generally modified for harvesting sunflowers. The conventional reel is replaced by a special 3-batt reel or a metal drum. Narrow strippers are attached to the front of the combine cutter bar to guide the heads backwards toward the knife and to prevent the heads from dropping to the ground.

Sunflower seeds are easily threshed from the heads so the cylinder speed may be reduced to one-half the normal speed for wheat. The concaves are generally opened wide to reduce breaking the heads into small pieces which may overload the chaffer.

The seeds are quite large and generally little trouble is encountered in chaffer, fan, and cleaning sieve adjustments unless there are excessive amounts of broken heads. (See reference 6.)

Grass Seeds—Varieties of grasses grown to produce seed include brome, Crested wheat, Reed canary, and Russian wild rye.

Straight combining is the simplest method of harvesting; however, the risk of shatter losses is high, as a high wind may completely shell a ripe standing field in a few hours.

Swathing should be done when the seeds are partially ripened and mature enough so that no shrinking results while drying in the swath.

Cylinder speed may be reduced to 200 rpm less than for wheat, and the concave clearance set so threshing is complete without peeling kernels and breaking the straw excessively.

Grass seeds are very light, so the wind setting is critical. Reduce the air blast by reducing fan speed as much as one-third or one-half and direct the air to the chaffer for most satisfactory flotation and separation. Inspect the tailings periodically to be sure no good seed is being blown over. It is generally acceptable to have as high as 20 percent dockage in the grain tank. This generally assures there is little loss during threshing. The dockage will be removed at the seed-cleaning plant. (See references 7, 8, 9, 10, 11, and 12.)

Combine Attachments

Pickups—The draper or belt type picks up stones to a lesser extent than the drum type.

Grain-Saving Guards (Pickup Fingers)—These are valuable aids in saving lodged or tangled grain. They may also help save sawfly-damaged grain. They do not work well in a crop that has lost its natural strength or has started to rot.

Pickup Reels—These consist of rake-like fingers instead of the standard reel and batts. They are extremely valuable in badly lodged grain or in grain that has been flattened by snow. Correct adjustment of the speed and timing of the reel is essential.

Strawchoppers—These attachments permit the straw to be more easily worked into the soil. They take from 3 to 8 horsepower to operate and may necessitate a reduction in forward speed of the combine.

Strawbunchers—These have been used with varying success where straw is needed for livestock. The common type collects the straw as it leaves the combine and deposits it in piles behind the machine. Other types collect chaff or both chaff and straw.

Balers—Low-density balers attach directly to the rear of the combine and produce twine-tied rectangular bales. The horsepower requirements are about the same as for strawchoppers. A conventional baler will produce a more acceptable bale.

Cabs—Improved cabs for combines are available. These add greatly to the comfort of the operator and reduce fatigue. Pressurized air systems with filters as well as air conditioners and heaters are available.

REFERENCES

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4. *Rapeseed: Canada's "Cinderella" Crop*. Rapeseed Association of Canada, 801-191 Lombard Avenue, Winnipeg 2, Manitoba.
5. *Production of Rape in Western Canada*. Publ. 1021. Canada Department of Agriculture.
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11. *Management of Bromegrass for Seed in Central Saskatchewan*. Publ. 1148. Canada Department of Agriculture.
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Other References

Alfalfa in Canada. Publ. 1377. Canada Department of Agriculture.
Sweet Clover in Western Canada. Publ. 998. Canada Department of Agriculture.

GRAIN-HANDLING MACHINERY

For greatest efficiency, grain augers should be operated at no more than a 45-degree angle to the ground. Grain bins may be arranged to make use of conventional augering equipment for moving grain in and out of storage. Plans of grain bin arrangements may be obtained from your agricultural representative, the Family Farm Improvement Branch, or from commercial manufacturers.

Following are the power requirements and the delivery capacity for the various auger tube diameters available.

Auger Tube Diameter (in.)	Length (ft)	Approximate Capacity (bu/min)	Recommended Gas Engine	Horsepower Electric
4	12	5	2½–3	1–1½
6	30–42	10	6–10	3–5
7	30–42	25	9–15	4–7½
8	30–42	50	11–18	
10	–42	100	40	

Careful augering of seeds which are easily damaged (e.g., malting barley, rapeseed, mustard seed, and sunflowers) is essential to prevent cracking. Keeping the auger tube full when in operation and reducing auger speed help to reduce kernel damage.

HAY AND SILAGE EQUIPMENT

Mowers—Drawbar-mounted, side-mounted, and trailer-type mowers are available with either hydraulic or mechanical lifts. There are both pitman and balanced-head sickle drives. While more expensive, the balanced-head type permits using the cutter bar at any angle up to 90 degrees from the horizontal. Serrated mower knives require no sharpening but generally do not work well in fine-stemmed crops, such as crested wheatgrass and wild grasses.

Combination mower-conditioners to 10 feet in width are available which cut, condition, and windrow in one operation.

Rotating disc-type mowers up to 8.5 feet wide are being imported from Europe. Knives set into discs rotating up to 3,000 rpm cut and windrow the hay.

Hay Conditioners—Crimpers and crushers, used to shorten the curing period, work best with legume crops. They should be set to slightly crush or crimp the plant stems, permitting them to dry at a faster rate. If enough power is available, the crimper or crusher should be attached to the mower or swather; otherwise, it should follow immediately behind and perform this operation before the plants have wilted. Heavy windrows may require turning to reduce drying time for the lower part of the windrow.

Windrowers or Swathers—Most types of grain swathers will increase the speed of mowing and windrowing. If the crop is for hay, a crimper or crusher may be required to reduce drying time for a heavy swath. Turning heavy windrows after the top has dried reduces overall drying time, so baling may be done sooner. In silage operations, a swather speeds cutting, permits wilting (if required), allows the forage harvester to operate at full capacity, and reduces travel distance of the harvester crew. (See reference 1.)

Rakes—A side-delivery rake should be used with balers and forage harvesters to produce a uniform windrow. In light crops two or more windrows may be raked together to form one large windrow to allow the baler to operate at capacity and to reduce baler travel distance in the field. Several types of rakes are available with either PTO or ground drive. Wheel and oblique reel types rake the windrow with less movement of the hay and may reduce leaf loss. Leaf loss will increase with increased speed.

Stackers and Sweeps

Various types of sweep stackers are used for handling loose hay. They may be fully tractor mounted, specially constructed, or may replace the bucket of the front-end loader; or they may be mounted on two wheels and pushed in front of the tractor. For successful sweep operation, the ground should be relatively smooth and hauling distance under one-half mile. Portable stacking frames reduce stacking time and make uniform-sized stacks which are easy to move.

Stack Movers

Movers are capable of handling stacks up to 16 feet wide and 30 feet long and weighing a maximum of 7 tons. Once loaded, stacks may be moved a considerable distance economically.

Balers

Baling is the most popular method of haying in Saskatchewan. Two types of balers are used, the most common making rectangular bales, the other forming round or cylindrical bales.

Balers may be self-propelled or pull type, operated by PTO shaft from the tractor, or by an auxiliary engine mounted on the baler.

When using a baler producing round bales, wide or double windrows side by side are necessary to produce uniform bales. Round bales, although more difficult to stack, withstand the weather in the field better than rectangular bales.

The production of high-density, rectangular bales puts additional strain on the baler, raises power requirements, and, if the density is excessive, increases tying problems. High-density bales are more durable and require less space for storage and hauling, but they must be drier than regular bales for safe storage.

Uniform windrows and proper adjustment of the feeding mechanism of the baler are essential for well-formed bales. Wet twine may cause tying problems.

Bale-Handling Equipment

Bale-handling equipment is available to attach to or pull behind the baler to gather bales into bunches, pyramids, or wagons to facilitate handling. Various methods and types of equipment may be used to pick up, haul, and stack the bales after they are dropped singly in the field behind the baler.

Mechanical-arm and elevating conveyor field pickups attach to wagons or trucks for loading bales in the field.

Commercial equipment for loading, hauling, and stacking bales includes bale throwers or ejectors on balers to deliver bales to the wagon behind the baler; attachments

for front-end tractor loaders, and automatic pickup and stacking wagons in either pull or self-propelled models.

Various manufactured and home-built devices, such as sleds, wheeled platforms, and automatic-type pyramid stookers, may be used behind the baler in the field to gather and bunch bales for more rapid loading by tractor loaders.

For stacking bales, the elevator conveyor is most commonly used. For placing bales in barn lofts, either the conveyor type or the ejector type works satisfactorily. Square bales make better use of space when randomly piled.

Forage Harvesters

Forage harvesters are available in three types: Reel, flywheel, and flail. These require wagons, with power-driven unloading mechanisms or dump boxes, to transport the chopped material to the storage or feeding area. A pneumatic or mechanical device is necessary if the material is to be conveyed to the silo.

The reel type has several advantages: It can cut the crop uniformly at one-half to three-quarters of an inch in length; it has high capacity; it is equipped with a mounted sharpening stone, which encourages frequent sharpening; it can be equipped with either a cutterhead or pickup head. The flywheel type is capable of producing a short, uniform cut but compared with the reel and flail it is limited in capacity, more complex in construction, and more costly to maintain. The knives of the flywheel type must be removed for sharpening. The flail type is the cheapest but has several serious disadvantages: The crop is cut longer and more unevenly than with the reel or flywheel; it is difficult to keep the knives sharp; under dry conditions it may suck up dirt; horsepower requirements are highest of the three types; in light crops harvesting losses are high.

Hay can be harvested more cheaply with forage harvesters than with a baler. Chopped hay may be placed directly into self-feeding storage. Labor requirements at harvesting time and during the feeding period are less for this method than for other mechanical methods. Field losses from weathering or shattering are reduced. Distance from field to storage is a limiting factor. Precautions should be taken to avoid "dusting" during chopping.

The forage harvester requires sufficient horsepower to maintain full recommended speed at all times. It is desirable to have a delivery spout which will swing to either side or to the rear. Its length and height should be sufficient to place the chopped crop directly into the centre of the wagon or truck. This provides safe loading and minimum loss on rough or hilly ground. (See Forage Crops section, page 58 and Livestock section, page 151.)

REFERENCE

Silage. Saskatchewan Department of Agriculture.

FEED-PROCESSING EQUIPMENT

Many factors influence the selection of feed-processing equipment. These include: 1. Volume of feed to be handled; 2. availability of equipment and service; 3. farmstead arrangement; 4. kind of livestock; 5. number of rations; 6. labor supply; 7. availability of capital; 8. tenure status.

For low volumes the fixed costs of owning equipment may result in higher processing costs than if a mobile feed mill or a commercial feed plant is used. When other services are available, about 100 tons of feed should be processed each year before considering the installation of on-the-farm grinding and mixing equipment.

Types of Mills

Hammer Mills—are the most popular type of grinder. They consist of a high-speed rotor with either fixed or hinged hammer and a heavy perforated screen. Both part-circle and full-circle screens are used. The screen opening size determines the fineness of grind. Screens are available with 1/32-inch to 2-inch openings. The larger sizes are used to process forage.

Both tractor PTO and electric-motor driven units are available. Compact electric-driven units have the mill rotor mounted on the motor shaft. Farm units of this type are available in sizes ranging from 1 to 40 horsepower. Many of the low-capacity units have metering or blending equipment incorporated into the machine. Capacity varies widely, depending on the material, fineness of grind, and size of the unit. Small electric units will process from 2 to 7 bushels per horsepower hour.

The feed produced by hammer mills is non-uniform in size, with considerable fine powdery material.

Roller Mills—are best suited for processing feed for cattle or horses. They consist of chilled cast iron or steel rolls, either of solid or tubular construction. The better quality chilled cast iron rolls should be hardened for a considerable depth below the surface. Rolls of this type may be regrooved. Rolls vary in size from 6 to 30 inches in diameter and from 4 to 42 inches long.

The primary disadvantage of roller mills is that grain of widely varying sizes cannot be properly processed simultaneously. Also, forages cannot be processed in a roller mill. Rolls may be damaged by foreign object such as stones or tramp iron.

The surface of the rolls is usually corrugated, although a satisfactory product has been produced with smooth rolls. The general recommendation for corrugated rolls varies from 6 per inch for corn, 7 to 9 for corn, wheat, or oats, and 12 to 15 for wheat, oats, or barley. Usually the fewer corrugations per inch, the longer the roller life before regrooving is required.

Roller mills produce a uniform coarse grind suitable for cattle but usually not fine enough for swine. The material is also not ground sufficiently fine for use in a liquid feeding system.

Steam processing of grain to modify or gelatinize the starch molecule prior to rolling is common practice in many commercial feed mills.

The capacity of roller mills varies with the grain moisture content, roll size, and available horsepower. For small units processing dry barley, the specific capacity varies from 15 to 30 bushels per horsepower hour.

Roller mills should be equipped with an independent roll-spacing adjustment at each end of the rolls. A simple quick roll-release mechanism is also desirable. It will permit clearing the rolls of grain; it is very difficult to start a roller mill with grain between the rolls.

Burr Mills—have a low initial cost but require periodic plate replacement.

They may be adjusted to produce a coarse or fine grind, although power requirements are high for fine grinding and the product may be dusty.

The principle of operation involves passing the grain between two roughened chilled cast iron plates. One plate is stationary; the other rotates. The pressure applied between the plates determines the fineness of grind. Usually no provision is made to limit plate spacing; thus, damage to the plates will occur if the unit is run empty.

Processing Systems

Several basic systems may be used to process feed; they include: An electric-driven stationary mill, tractor PTO-operated mill and batch mixer, tractor-driven mobile grinder mixer, custom mobile mills, and commercial feed mills.

Electric Mills—These units may be incorporated into an automatic system requiring little or no labor. Careful planning of bin locations, transfer augers, and other equipment is essential for a trouble-free system.

Tractor Mills and Batch Mixers—These units have the advantage of high capacity but tractor costs and labor requirements usually make them expensive. A roller mill, hammer mill, or plate grinder is used. A separate batch

mixer or mixer wagon is required to produce a complete ration. The hammer mill can also process roughage. A two- to three-plow tractor should process 1 to 2 tons per hour of alfalfa hay through a 14- to 16-inch-wide hammer mill with a screen having 1½-inch openings.

Mobile Grinder Mixers—These combine processing and distribution equipment in a single unit. They are portable and can be powered from a tractor PTO. Partial breakdown can disable an entire unit. The portable feature may be an advantage where feed storage is widely separated. Good all-weather roads are essential when tractors are used to transport feed.

Custom Mobile Mills—Producers entering the livestock business or having low to medium feed volume requirements should consider using the services of a mobile mill. These units can process farm-grown feeds, add supplement and molasses if desired, and deliver the mixed feed into storage bins.

Commercial Feed Mills—Sometimes it may be more economical to haul farm-grown grain to a feed mill and exchange it for processed feed. The advantages are: No capital outlay for equipment and an accurately proportioned and mixed ration. These, however, must be balanced against the cost of hauling, the labor involved in loading the grain and unloading the feed, and the cost of processing. Commercial mills usually can supply special products such as pelleted feeds and concentrates. Pellet mills are very expensive and their installation on the farm can be justified only by a very large enterprise.

Mixers—These are of three general types: Horizontal, vertical, and auger wagon. A horizontal mixer costs about three times as much as a vertical mixer. It also requires considerably more power, but it does the mixing in 3 to 4 minutes, compared with 15 minutes for the vertical type. The auger wagon with attachments for mixing will cost about one-third more than a vertical mixer. When using an auger wagon make sure that the ration is completely mixed.

Feed Processing Costs—Cost analyses are usually made on a unit basis. For convenience, the total is broken down into fixed and operating costs. Normally, fixed costs are not directly related to the amount of use; they include depreciation, interest on investment, housing, and insurance. Operating costs are directly related to use; they include fuel, power and utilities, labor, maintenance, and repairs.

The following example illustrates the procedure by showing how to determine the cost per ton to process and distribute 200 tons of feed per year with a mobile grinder mixer.

	Mobile grinder mixer	$1800.00
	Bin unloading equipment	200.00
	Investment	2000.00
Assumptions		
Mill capacity	3.5 tons/hr	
Set up and distribution time	0.25 hr/ton	
Depreciation	10 years	
Salvage value	10% of cost	
Interest	7% per year	
Maintenance and repair	0.20/ton	
Tractor cost	2.00/hr	
Labor cost	1.00/hr	
1. Fixed cost		
Depreciation (straight-line method)		$180.00
Interest on average investment		77.00
Housing and Insurance at 1.00/1000.00		2.00
		259.00
Unit cost		1.30/ton
2. Operating cost		
Tractor 0.5 hr/ton		1.00
Labor 0.5 hr/ton		.50
Repairs		.20
		1.70/ton
Total cost per ton to process and distribute 200 tons of feed per year		$3.00/ton

Analyses of this type are a useful guide in decision-making. The results, however, are no more valid than the initial assumptions, so care should be taken in planning the capital and labor inputs for each alternative system being considered.

Additional information on how to plan feed handling systems may be obtained from the Agricultural Engineering Department, University of Saskatchewan, and the Family Farm Improvement Branch, Regina.

Types of Silos

In deciding the type of silo to build, consideration should be given to the equipment that will be needed for filling the silo and to the method of feeding. Upright silos are more expensive than horizontal types and the equipment for filling and emptying may also be more expensive. This high initial cost may be offset by reduced storage losses and the possibility of automatic feeding. Self-feeding from horizontal silos can result in high losses; moving silage out of a horizontal silo for consumption elsewhere is a daily chore involving considerable labor.

1. **Upright**—Upright silos of wood stave, concrete stave, and cast-in-place concrete are becoming increasingly popular in Western Canada. Freezing of silage near the walls is not so much of a problem with silo unloaders as it was with manual labor.

Uneven settlement due to inadequate foundations has caused silos to tilt and even to collapse in a few cases. A properly designed foundation is particularly necessary if the silo height is more than three times the diameter or if the height exceeds 40 feet.

2. **Horizontal**—Horizontal silos are lower in initial cost than upright silos. However, they are not suitable for storing haylage and automatic feeding systems are only economically feasible for very large operations. Both site and silo require drainage with a minimum slope to the silo floor of 1 foot per 100 feet of length.

Concrete floors in horizontal silos add to the cost of a silo but are essential for self-feeding. Moveable gates or electric fence installations prevent animals from tramping or wasting silage at the feeding face. Producers must be concerned about "clean housekeeping" if feed wastage is to be avoided.

(a) **Trench**—Trench silos are popular where they can be cut into the side of a hill or creek bank. However, a rise of only 3 or 4 feet provides a good location when the sides are built up with the excavated soil. Soil from a dugout excavation can be used to make silos on level ground. In sandy soils, the walls can be lined with concrete or pressure-treated lumber to prevent them from caving in.

(b) **Bunker**—Walls for bunker silos may be of pressure-treated wood or of concrete and should be erected with a slope of 1 foot for every 8 feet of height. The walls should be tight and must be well braced.

Tables IV and V may be used as a guide in selection of silo sizes.

TABLE IV
Guide to Horizontal Silo Sizes*

Number of cows	Average width (ft)	Average depth (ft)	Required length of silo (ft) 150 days feeding	180 days feeding	210 days feeding
25	16	6	39	47	55
50	20	6	63	75	88
75	20	8	70	84	98
100	24	8	78	94	110
150	28	10	80	97	112

*Calculated on the basis of silage at 40 lb per cu ft and a daily ration of 40 lb of silage per animal.

TABLE V
Guide to Upright Silo Sizes*

Number of Cows	Diameter of Silo (ft)	Required Height of Silo (ft)		
		150 days feeding	180 days feeding	210 days feeding
50	14	39	47	55
	16	30	36	42
75	16	45	54	63
	20	—	35	40
100	20	38	46	54
	24	—	33	38

*Calculated on the basis of silage at 50 lb per cu ft and daily ration of 40 lb of silage per animal.

Hay-Drying Equipment

Hay placed in storage at a moisture content of 35 percent can be dried mechanically using unheated air for an operating cost of approximately 50 cents per ton. When hay is handled in this way, field losses due to weathering and shattering of leaves are greatly reduced, resulting in more hay of better quality. Spontaneous combustion of hay in storage is much less likely to occur if drying is practised.

When a hay-drying fan is used, hay can be cut one day and put in storage the next. Only as much hay as can be handled the following day should be cut; a conditioner should be used to speed drying. Bales should be of medium density to permit air flow through them.

The drying system consists of a fan, a main duct approximately 4 feet by 5 feet, and false floor of slatted or wire mesh construction. The fan should be able to deliver at least 500 cfm per ton of hay against a pressure of 1 or more inches of water. Installation cost of fan, motor, and floor will be of the order of $1,500.

The Saskatchewan Department of Agriculture currently offers a grant of 15 percent of the capital cost of an approved forage structure up to a maximum of $200. Further information available can be obtained from district agricultural representatives or the Family Farm Improvement Branch.

Miscellaneous Machinery

Equipment for handling many farm materials is available from reputable distributors. It includes feed bunk augers, self-unloading wagons, barn cleaners, manure spreaders, liquid manure tanks, silo unloaders, bale or grain elevators, grain augers, livestock waterers, limit feeders for hogs, etc. When properly installed and used most of this equipment will perform as described by the manufacturers.

The value of the equipment to a farmer will depend on its being used to do work for which labor is not available, or to reduce wastage. Many items may add to the convenience of a farm operator but, unless integrated into a planned system, may not increase the efficiency of the enterprise.

REFERENCE

Silage. Saskatchewan Department of Agriculture.

MANURE-HANDLING EQUIPMENT

This includes chain barn cleaners, manure spreaders, vacuum liquid manure tanks, and recirculating chopper pumps.

Chain gutter cleaners are more commonly used in dairy barns and occasionally in hog barns for removing solid manure from the barn to a manure spreader.

Liquid manure disposal systems are successfully used in many modern hog enterprises. The liquid manure is stored either in gutters or larger cisterns and is pumped out and hauled to the field for spreading. On most livestock operations, vacuum-tank trailers are used to empty gutters. To agitate and empty large storage systems, a more satisfactory method is to use recirculating chopper pumps. This type of pump is a necessity if cattle manure is to be handled as a liquid. Before liquid manure is agitated within a closed building, livestock should preferably be removed. Adequate ventilation should occur before people or livestock re-enter the building.

GRAIN-DRYING EQUIPMENT

Occasional years of unfavorable harvest weather conditions have shown that a grain dryer can permit earlier harvesting than an extra combine. Experience has also shown that a system of bins and conveying equipment must be provided to make the best use of a grain dryer, particularly at harvest time.

Grain can be dried in an hour or two in a number of types of commercially available dryers or it can be dried much more slowly in storage, using unheated air or air heated 10 to 20 degrees. Many commercial machines can dry a thousand or more bushels per day; drying in storage is usually suitable for only a few thousand bushels during the harvest time

Commercial Heated-Air Dryers

The greatest danger in heated-air drying is that excessively high temperatures will damage the grain. Table VI gives recommended maximum air temperatures. It will frequently be necessary to use temperatures lower than the values shown in the table.

TABLE VI
Recommended Maximum Air Temperature for Heated-Air Drying

Type of Dryer	Temperature of Hot Air °F		
	Milling and Durum Wheat	Rapeseed, Mustard, Flax, and Feed Grains	Malting Barley and Seed Grains
Batch	135	180	100
Recirculating	130–150	200	110
Continuous	120–140	180	110

The safe drying temperature is affected by the amount of moisture removed; damage is much less likely to occur if 2 percent of the moisture is removed than if the moisture content is reduced by 6 or 8 percent. If more than 4 percent of the moisture is removed, the values to Table VI for milling wheat should be reduced. Damage due to overheating is also more likely to occur when drying in cold weather than in the early fall. Temperature indicators on dryers may be in error by 20 degrees or more.

Drying in Storage

Where unheated air is used, the rate of drying will depend on the weather conditions. Little drying will take place in cool, damp weather and drying may be so slow that operation of the fan is uneconomical, particularly if the air temperature is below 50°F. In warm, sunny weather the fan should be operated for all but a few hours a day. Even when weather conditions are unsuitable for drying, an installation of this type can be used to force cold air through the grain, thereby cooling it and temporarily preventing spoilage. Grain with up to 20 percent moisture can be safely stored over winter if the temperature of the grain mass is kept below freezing.

Practical depths of grain for in-storage drying are from 4 to 8 feet. Recommended minimum rates of air flow range from 1 cubic foot per minute (cfm) per bushel for grain with less than 16 percent moisture, to 3 cfm per bushel for grain with 20 percent. Not all types of fans are suitable for forcing air through grain, since pressures of 1 to 3 inches of water on a manometer will be required, depending on the depth and kind of grain being dried. It is

important that air flow be uniform through all parts of the grain mass. A properly designed duct system or false floor must therefore be used.

If the air is heated 10 to 20 degrees, drying will be faster and will continue even when humidities are high. However, if it is heated more than 20 degrees, the lower layers of grain will be overdried and moisture may condense on the bin walls and roof. The depth of grain should be reduced to 3 feet or less when the air is heated by more than 20 degrees.

Aeration

Grain can be cooled to prevent spoilage with relatively simple equipment and low rates of air flow. A fan that will draw one-twentieth cfm per bushel through a grain bin will cool the contents to within a few degrees of the outdoor temperature in a week or two. This low rate of air flow will produce little or no drying.

Drying Costs

These include fuel, electricity, extra labor, and the equipment. Fuel and electricity will generally cost from ½ cent to 4 cents per bushel depending on weather conditions and the amount of moisture removed. The equipment may cost more than this per bushel unless a great deal of grain is dried.

Samples

When dried grain is sampled for moisture content or milling tests, care must be exercised to get a truly representative sample because of the variations in moisture content which may exist. The outer surface of freshly dried grain may be drier than the interior, so electric moisture meters may give a false reading until a few hours after drying has been completed.

Farmers using grain dryers should take advantage of the free testing service for milling grades of wheat offered by the grain research laboratories. Elevator agents have been supplied with instructions as to how to prepare samples for the above test.

SEED-CLEANING MACHINERY

The cleaning of seed grain is accomplished by distinct separations based on differences in kernel weight, width, length, adhesion characteristics, and foreign material to be rejected.

Separations may be made using combinations of two or more of the following cleaners, one of which must be a Carter disc or an indent cylinder machine: Fanning mill, fanning mill with corrugated rolls, corrugated roll grader, Carter disc, indent cylinder, combination scalper and grader, blanket cleaners.

TABLE VII
Kernel Characteristics Used by Machines in Cleaning Grain

Machine	Length	Weight	Width	Adhesion Characteristics
Disc machine, e.g., Carter	X			
Indent cylinder	X			
Fanning mill	X	X	X	
Roll grader			X	
Scalper and grader combination	X	X	X	
Precision grader	X			
Blanket cleaner				X

A recommended farm grain-cleaning unit having a capacity of approximately 40 bushels per hour consists of a 40-inch or larger improved fanning mill used in combination with a small Carter disc or indent cylinder machine. The machine may be mounted on a platform with suitable elevators or augers to provide for continuous operation. The fanning mill may be mounted high enough to deliver its cleaned grain directly into the hopper of the Carter disc or indent cylinder. For most efficient cleaning a Carter disc should be operated as near capacity as possible at all times. If a gasoline engine is used, higher capacity from the Carter disc may be obtained by mounting the engine on a separate platform to give smoother operation.

Custom-operated or co-operative grain-cleaning plants, such as those now in use in many Saskatchewan centres, are recommended. A good operator must be available. The practice of cleaning seed grain in country grain elevators is not ordinarily recommended because of possible contamination from other seed lots.

To clean efficiently, the through-put of grain must be matched to the capacity of the machine. For small mills this is usually in the range of 15 to 25 bushels per hour.

Further information on seed-cleaning plants may be obtained from your agricultural representative, or the Extension Division, University of Saskatchewan, Saskatoon, or Family Farm Improvement Branch, Regina.

REFERENCES

Seed Cleaners and Separators. Publ. 1061. Canada Department of Agriculture.
Seed Cleaning in Saskatchewan. Saskatchewan Department of Agriculture.

SEED-TREATING EQUIPMENT

Machines are now available for applying dusts or liquids, or a combination of the two, to control disease and wireworms. Most of these machines are too expensive for farm use, but they are generally found in many custom seed-cleaning plants.

Special seed-treatment applicators are available for attachment to auger-type grain loaders. They can be calibrated to apply the correct amount of chemical, provided the quantity of grain passing through the augers per minute or per hour is known. Auger flight speed (rpm) is not important at treatment rates of up to 250 bushels per hour with wheat or barley. At rates of 350 to 400 bushels per hour the auger should turn at 800 rpm. Seed treatment with a grain auger is not recommended at rates higher than 400 bushels per hour.

Treaters are now available which attach to the outlet of drill fill augers to treat grain as the drill box is being filled.

Dusts and liquids are highly poisonous and care must be exercised in their use. Grain augers suitable for treating seed are relatively inexpensive and should not be used for any other purpose.

It is a criminal offense to sell contaminated grain which has been treated with chemicals. Augers used for treating grain must be thoroughly cleaned before augering commercial grain.

LAND-CLEARING EQUIPMENT

Rotary mowers operated by a farm tractor PTO will demolish the top growth of weeds and woody plants up to 2 inches in stem diameter. Good control of brush regrowth can be obtained on pasture land by following up the cutting operation with proper stocking rates. The use of rotary mowers should be considered as an alternative to the use of herbicides, particularly on small acreages and where legumes are present in the sward. (See Weed Control section, page 74.)

Extreme caution must be exercised in operating rotary mowers because the cut material ejected at high velocity

is dangerous. Guards are necessary to protect the operator and tractor radiator from standing brush.

Land is most commonly cleared by dozer equipment in winter or by V-type blade cutters and toothed piler equipment in summer.

A weighted cable or chain is effective for swathing down brush on a large scale. This method is generally applicable to projects of more than 500 acres. Several farmers may group together to obtain sufficient acreage to attract a contractor with this type of equipment.

The size and density of the brush that can be handled by the weighted chain method will depend on the size of the tractors available for towing the chain. Two tractors of at least 150 horsepower each are required for bush up to 5 inches in stem diameter, and 200 or more horsepower each for bush with trees greater than 5 inches in stem diameter. When the soil is frozen and the temperature is well below freezing, the tree growth tends to break off at the crown of the root instead of being uprooted. The windrowing effect of the chain reduces piling costs, and less power is required if piling is delayed sufficiently to allow the brush to dry. Effective burns can often be obtained on the windrows left by the chain and this may contribute to a further reduction in piling costs.

Cleared areas can be broken with breaker-bottom moldboard plows, heavy-duty disc plows, or heavy-duty rototillers. Tractor-mounted root rakes are also available, although a considerable amount of hand picking is often necessary.

The following are the approximate costs per acre that may be expected using various methods of clearing and land preparation.

rotary mowers	$ 3.00— 8.00 per acre
dozer equipment—knocking down	5.00— 8.00 per acre
V-type brush cutter	5.00—10.00 per acre
dozer equipment—piling	10.00—18.00 per acre
chain equipment—swathing	2.00— 5.00 per acre
dozer equipment—piling after chaining	6.00—16.00 per acre
breaking with heavy disc equipment	5.00— 9.00 per acre
working down with light disc equipment	2.00— 3.00 per acre
rotary root rake	3.00— 5.00 per acre
rototilling	10.00—20.00 per acre

Breaking, working down, and root-raking operations may be replaced by rototilling where stones are not a problem. Rototilling to a 5-inch depth provides a good seed-bed.

EQUIPMENT FOR APPLYING AGRICULTURAL CHEMICALS

General-purpose sprayers apply chemicals at low pressure for weed and insect control and at high pressure (200 to 500 pounds per square inch) for pest control in trees, livestock, and buildings. (See Insect Pests section.)

Low-volume, low-pressure (30 to 50 pounds per square inch) boom-type sprayers operate at about 4 miles per hour and apply 4 to 10 gallons per acre for the control of weeds and insects in field crops. They may be truck, trailer, or tractor mounted and are driven from the tractor power takeoff or by an auxiliary engine. They may be adapted to other uses, such as the spraying of cattle to control warble fly. Booms may be attached to self-propelled swathers, harrow hitches, and other farm machinery.

Nozzles should be calibrated before machines are used, and worn or defective nozzles should be replaced. Considering the high cost of chemicals, a 10 percent increase in nozzle delivery due to wear can result in serious inefficiencies in applying chemicals. Nozzles with greater capacity are required when recommendations on the label call for a higher than usual number of gallons of solution per acre.

Checking the condition of sprayer pumps each season is recommended. The pump should have adequate capacity to maintain spraying pressure as well as provide enough bypass flow for agitation of the chemical in the tank. Four gallons per minute (gpm) must be bypassed to obtain effective agitation of wettable powder in a 100-gallon tank. Mechanical agitation is preferable.

A pump having a higher delivery rate may be required when using higher volume nozzles such as used in applying Avadex. Pumps with nylon rollers are now widely used for sprayers. Gear or piston pumps should not be used with abrasive wettable powders, but they can be operated with fine sprayable powders such as Sevin. Piston-type pumps must be used when high pressures are required. The diaphragm pump has a long life when operated with wettable powders but its cost is high.

When certain wettable powders are used, felt filters will need to be replaced by screens. The nozzle screens should be from 60 to 100 mesh. Use the finest mesh suitable for a particular chemical.

Boom-type sprayers may be used to apply liquid nitrogen solutions. However, because of the corrosive nature of nitrogen, sprayer parts such as tank, pump, booms, and nozzles must be of non-corrosive materials.

Maximum benefit from chemicals will be obtained if the following points are observed in sprayer operation:

1. Use clean water; 2. clean filters frequently; 3. calibrate the sprayer yearly. When speed or pressure is changed during spraying, the sprayer should be recalibrated; 4. carefully determine the correct amount of chemical to be added to the tank when filling; 5. mix the chemical and water thoroughly in the tank before starting to spray; 6. adjust the boom to the proper height; 7. maintain a constant spraying pressure; 8. maintain a constant spraying speed; 9. reduce boom whip to a minimum; 10. keep the sprayer in good mechanical condition.

Procedures for field calibration and calculating the correct amount of chemical to add to the tank are contained in bulletins listed below.

Farm sprayers equipped with a special short boom using 50-gallon-per-acre nozzles may be used to control weeds in shelterbelts; however, care must be taken not to spray the tree foliage. Boomless sprayers are well adapted to roadside spraying. (See Shelterbelts, page 134.)

Aircraft can be a fast and efficient means of applying pesticides providing certain precautionary measures are taken. Wind direction and wind velocity limits must be strictly observed in order to prevent uneven application and excessive spray drift. Water used as a carrier tends to reduce spray drift.

REFERENCES

Farm Sprayers. Publ. 1157. Canada Department of Agriculture.
Weed Sprayer Operation (Saskatchewan Advisory Weed Council). Saskatchewan Department of Agriculture.

RURAL ELECTRIFICATION

Electric wiring systems should be adequate, safe, economical, and convenient.

Safe wiring systems minimize the dangers of fire and electrical shock. To ensure safe systems, only equipment and appliances bearing the Canadian Standards Association (CSA) stamp of approval should be used. All wiring systems should be inspected and approved by the Electrical Inspection Branch of the Saskatchewan Department of Labor. Refusal to discontinue use of unapproved equipment or wiring may result in the power supplier being ordered to disconnect the service.

To facilitate inspection and ensure safety a Form J permit must be obtained before installing, altering, or extending wiring. This permit, along with a schedule of the necessary fees, may be obtained from the Electrical Inspection and Licensing Branch, Department of Labor, Regina.

Adequate wiring is designed with sufficient capacity to operate properly all lights, motors, and appliances which may be used now or in the foreseeable future. To ensure adequate wiring, planning is essential. Scale drawings of farm buildings showing their size and relative location are helpful in planning the location of the meter pole and the length of feeders.

In planning and selecting equipment for an electrical system, capacity and circuits should be adequate for future growth. It is cheaper to wire completely and adequately at the start than to make numerous additions and repairs later.

TYPES OF ELECTRICAL SERVICE

Most Saskatchewan farms are supplied with 115-230 volt, 60-cycle, single-phase electric power. Three-phase service is available in special cases, usually where the farm is adjacent to a three-phase line.

ELECTRIC MOTORS

Single-phase, alternating current motors can be divided into eight general types: 1. Split phase; 2. capacitor-start induction-run; 3. capacitor-start capacitor-run; 4. permanent split capacitor; 5. repulsion-start induction-run; 6. universal or series; 7. shaded pole; and 8. soft start.

A summary of the ratings and use of the various types of motors is shown in Table VIII.

TABLE VIII

Electric Motor Selection and Summary

Motor Type	Hp Range	Starting Torque	Starting Current	Reversing Method	Characteristics	Typical Uses
Split-phase	1/6-¾	Low, 1.5 to 2 times rated load	High, 6 to 8 times rated current	Electrical*	Inexpensive, simple construction	Fans and blowers Washing machines Shop tools Jet pumps
Capacitor-start induction-run	1/6-10	4 times rated load	3 to 6 times rated current	Electrical*	Versatile motor, most popular for farm use	Water systems Grain augers Air compressors Milking machines Ventilating fans Agitators and mixers
Capacitor-start, capacitor-run (two-valve capacitor)	2-20	4 times rated load	3 to 5 times rated current	Electrical*	Special capacitor gives improved performance in breakdown torque, full load efficiency, and power factor	Silo unloaders Large conveyors Barn cleaners Silage blowers Pumps Crop-drying fans Bunk feeders Hammer mills
Repulsion-start, induction-run	1/6-20	5 times rated load	3 times rated current	Shift brushes	Expensive, handles large loads with little variation in current	Silo unloaders Barn cleaners Large conveyors Mixers Deep well pumps Feed grinders
Permanent-split capacitor	1/6-¾	60% of full load torque	5 to 6 times rated current	Electrical*	Usually constructed for custom applications. Maintenance requirements are low	Fans and blowers
Universal (Series)	1/40-2	8 to 10 times rated load	8 to 10 times rated current	Not usually reversible	Speed is controlled by the load. Motor contains a commutator and brushes which require maintenance	Hand tools Vacuum cleaners Sewing machines Hair clippers Small food mixers
Shaded pole	1/20-1/6	50% of full load	1½ times rated current	Not usually reversible	Light-duty motor for small loads	Small fans Hair dryer Car warmer fan
Soft-start motors	7½-50	50 to 90% of rated load	2 to 2½ times rated current	Electrical*	Motors have special windings which allow relatively low starting current requirement	Crop-drying fans Forage and silo blowers Feed grinders Centrifugal pumps
Three-phase motors	½-400 or more	3-4 times rated load	3-4 times rated current	Electrical*	Requires three-phase power or a phase converter may be used on single-phase lines. Simple construction, versatile, trouble-free motor	Irrigation pumps Manure pumps Feed grinders Large conveyors Bucket elevators Mixers

*Reversing electrically is done by changing wires at the motor terminals.

Motor Bearings

Electric motors are equipped with two types of bearings. Sleeve-bearing motors are the less expensive. They require lubrication and normally should be mounted only in a horizontal position. Ball-bearing motors may require periodic lubrication or they may be sealed permanently. They can be mounted in any position. However, they should not be expected to carry excessive thrust loads.

Wire-Size Selection

Tables IX and X may be used in selecting the proper size wire for electric motors. Table IX is for copper conductors and Table X for aluminum.

TABLE IX

Copper Conductors, Single-Phase Motors: 115-230 Volt, 2 Percent Voltage Drop

Motor Hp	Rated Volts	Full Load Amp.	Minimum Allowable Size of Conductor: In Cable Conduit, Earth: Types R-60, RW-60, T, TW, TWU, RWU	Minimum Allowable Size of Conductor: In Cable Conduit, Earth: Types R-75, RW-75, TWH	Minimum Allowable Size of Conductor: Overhead in Air*: Bare and Covered Conductors	Length of Run in Ft. Compare size shown below with size shown to left of double line: 50	75	100	150	200	250	300	350	400	500
1/6	115	4.4	14	14	10	14	14	12	10	10	8	8	8	6	6
1/4	115	5.8	14	14	10	14	14	12	10	10	8	8	6	6	6
1/3	115	7.2	14	14	10	14	12	12	10	8	8	6	6	6	4
1/2	115	9.8	14	14	10	14	12	10	8	6	6	4	4	4	3
3/4	115	13.8	12	12	10	12	10	8	6	6	4	4	3	3	2
1/6	230	2.2	14	14	10	14	14	14	14	14	12	12	12	10	10
1/4	230	2.9	14	14	10	14	14	14	14	14	12	12	12	10	10
1/3	230	3.6	14	14	10	14	14	14	14	12	12	10	10	10	10
1/2	230	4.9	14	14	10	14	14	14	14	12	12	10	10	10	8
3/4	230	6.9	14	14	10	14	14	14	12	12	10	10	10	8	8
1	230	8	14	14	10	14	14	14	12	10	10	10	8	8	6
1½	230	10	14	14	10	14	14	12	10	10	8	8	8	6	6
2	230	12	12	12	10	12	12	12	10	10	8	8	6	6	6
3	230	17	10	10	10	10	10	10	8	8	6	6	6	4	4
5	230	28	8	8	10	10	10	8	6	6	4	4	3	2	2
7½	230	40	6	6	10	10	8	6	4	4	3	2	2	1	0
10	230	50	4	6	8	8	8	6	4	3	2	2	1	0	00

*Conductors in overhead spans must be at least No. 10 for spans up to 50 ft and No. 8 for longer spans.

TABLE X

Aluminum Conductors, Single-Phase Motors: 115-230 Volt, 2 Percent Voltage Drop

Motor Hp	Rated Volts	Full Load Amp.	Minimum Allowable Size of Conductor: In Cable, Conduit, Earth: Types R, T, TW	Minimum Allowable Size of Conductor: In Cable, Conduit, Earth: Types RH, RHW, THW	Minimum Allowable Size of Conductor: Overhead in Air*: Bare and Covered Conductors	Length of Run in Ft. Compare size shown below with size shown to left of double line. Use the larger size: 50	75	100	150	200	250	300	350	400	500	600	700	800	900	1,000
1/6	115	4.4	12	12	10	12	12	10	8	8	6	6	6	4	4	2	2	2	2	1
1/4	115	5.8	12	12	10	12	10	10	8	6	6	6	4	4	2	2	2	1	1	0
1/3	115	7.2	12	12	10	12	10	10	8	6	6	4	4	4	2	1	1	0	0	00
1/2	115	9.8	12	12	10	10	8	8	6	4	4	2	2	2	1	0	0	00	00	000
3/4	115	13.8	10	10	10	8	8	6	4	4	2	2	1	1	0	00	000	000	0000	0000
1/6	230	2.2	12	12	10	12	12	12	12	12	12	12	10	10	10	10	8	8	8	8
1/4	230	2.9	12	12	10	12	12	12	12	12	12	10	10	10	8	8	8	6	6	6
1/3	230	3.6	12	12	10	12	12	12	12	12	10	10	10	8	8	8	6	6	6	4
1/2	230	4.9	12	12	10	12	12	12	12	10	0	8	8	8	6	6	6	4	4	4
3/4	230	6.9	12	12	10	12	12	12	10	10	8	8	6	6	6	4	4	4	2	2
1	230	8	12	12	10	12	12	12	10	8	8	6	6	6	4	4	4	2	2	2
1½	230	10	12	12	10	12	12	10	8	8	6	6	6	4	4	2	2	2	2	1
2	230	12	12	12	10	12	10	10	8	6	6	6	4	4	2	2	2	1	1	0
3	230	17	10	10	10	10	10	8	6	6	4	4	2	2	2	1	0	0	00	00
5	230	28	6	8	8	8	8	6	4	2	2	2	1	0	00	00	000	0000	0000	0000
7½	230	40	4	6	8	8	6	4	2	2	1	0	0	00	000	0000	0000	250M	300M	300M
10	230	50	2	4	6	8	4	4	2	1	0	00	00	000	0000	250M	300M	300M	350M	400M

*Conductors in overhead spans must be at least No. 10 for spans up to 50 ft and No. 8 for longer spans.

Note: Voltage drop on starting will depend upon type of motor and nature of load. For starting current 3 x full load current, voltage drop = 6%; for 4 x full load current 8%; for 5 x full load current, 10%.

Motor Protection and Control

Motors must be protected against short circuit and overload. Ordinary circuit fuses or circuit breakers do not protect them; they protect only the circuit wires. Additional motor protection can be provided by: 1. Time-delay fuse; 2. motor-starting switches, (a) manual, (b) electromagnetic; 3. thermal-overload switch built into the motor, (a) automatic reset, (b) manual reset.

A time-delay fuse of the proper size gives the least expensive type of motor protection. Manual and electromagnetic motor-starting switches usually incorporate a thermal-overload relay, which acts as a protective device. The magnetic motor starter is the best method of controlling motors. It should be used for all motors larger than 1 horsepower and is essential in automatic control systems.

The built-in thermal-overload switch gives the motor the best protection from overload. The manual-reset type is recommended for general-purpose use and particularly for such equipment as saws and augers, or for jobs in which a safety hazard would exist should the motor start unexpectedly after stopping due to an overload.

Motor Operating Conditions

Electric motors must frequently operate under adverse conditions because of excessive dust, moisture, explosive gases, etc. Three types of motor housing are adaptable for farm use: 1. Open, drip-proof; 2. splash-proof; 3. totally enclosed.

Drip-proof motors are suitable where the surrounding air is clean and dry. They should be selected whenever possible, since they are the most economical. The splash-proof cover should be selected when there is danger of liquids splashing against the motor from the sides. This type costs more but the cover protects the motor windings.

Fully enclosed motors should be used where there is excessive dust, e.g., in feed mills. This type costs more initially but a saving will result from reduced maintenance, making it cheaper in the long run for this use.

Motor-Size Selection

Large-capacity equipment considered essential when gasoline engines were in use is not always necessary with electrical power. By the addition of automatic controls, constant supervision of equipment is not necessary and a motor can be allowed to operate over a much longer period than would be practical with a gasoline engine.

A 1-horsepower gasoline engine can be replaced by a ¾-horsepower electric motor. A 3-horsepower motor should be adequate to replace a 5-horsepower engine. When a machine is converted from hand operation, a ¼-horsepower motor should be adequate.

The introduction of soft-start motors and phase converters will permit the use of larger motors on single-phase lines. The use of this equipment with larger motors does not eliminate the need for adequate transformer capacity to operate the motor. Commercial phase converters, both static and rotary, are available.

Static-type phase converters require special motor wiring. Usually one converter is required for each motor. They are, however, usually cheaper for one- or two-motor installations than a rotary converter. Rotary-type converters can operate more than one motor at one time. With multiple-motor installations, any number of motors having a total rating up to **three** times the converter rating may be used, provided no single motor is rated higher than the converter. Three-phase motors either wye or delta connected can be used with no special wiring.

The Saskatchewan Power Corporation has also developed a relatively simple phase-converter system. Plans are available from the Corporation.

ELECTRICITY FOR HEAT

Electricity is a safe, convenient, economical source of energy for local heating. Agricultural applications include water heating, frostproofing, soil heating, brooder and space heating, underfloor heating of concrete floors, and de-icing of sidewalks and steps.

Water-heating appliances include: portable electric pail heaters, (1,500 watts); poultry water warmers, (100-250 watts); stock-water de-icers, 1. floating type, (1,000-1,500 watts); 2. immersion type, (1,000-2,000 watts); frostproof automatic livestock water bowls, (250-500 watts); domestic hot-water heaters, (1,000-3,000 watts).

Frostproofing, Soil, and Underfloor Heating

Plastic heating tape, (15-150 watts): Plastic-covered heating wire equipped with a thermostat set for 38°F is useful in preventing pipes from freezing. The manufacturers' instructions should be carefully followed when using this tape.

Heating cable: Heating cable is available in a wide range of sizes and lengths and is nylon jacketed for use in corrosive locations. It can be operated at higher temperatures than heating tape. The temperature should be controlled with a thermostat. A hotbed can be heated electrically with plastic-covered, lead-sheathed or copper-covered heating cable buried 6 inches in the soil. Approximately 16 watts per square foot of hotbed surface is required to maintain a soil temperature of 70° to 75°F for seed germination. The heating cable should be protected with a wire mesh set 2 inches above it.

Underfloor installation of heating cable can provide warmth for young livestock. However, unless barn temperatures are high, auxiliary heat in the form of heat lamps will be required for very young stock and chicks. Heating cable should have an installed capacity of 40 watts per square foot for farrowing pens, and 30 watts per square foot for weanlings. A floor temperature of 85° to 95°F is suggested for newborn pigs. As they grow older the temperature should be reduced 5 to 8 degrees per week. For snow-melting on sidewalks and driveways, 55 watts per square foot capacity is suggested.

Radiant Heating

Heat lamps (250 watts): Infrared heat lamps are suitable for chick and pig brooding as well as providing local heat for other young livestock or for a comfortable working area in an otherwise unheated milking parlor or farm shop. When used for brooding chicks, one 250-watt lamp should be adequate for 70 to 80 birds.

The following points should be noted when installing heat lamps: 1. Only pyrex glass bulbs should be used (plain glass may break if splashed with water); 2. only heat-proof, keyless sockets should be used; 3. the bulbs should be protected by a reflector equipped with a guard that will direct the lamp upwards if the unit is knocked down; 4. the lamps should be suspended at least 18 inches above the litter by a wire or chain, not by the electric cord; 5. the lamps should be plugged into an overhead receptacle, not connected to an extension cord. Any slack cord should be looped and taped so that the unit will become unplugged if it is pulled down; 6. not more than five 250-watt bulbs can be operated safely from a single 115-volt branch circuit.

Quartz-tube radiant heaters (1 to 10 kilowatt infrared): These are suitable for local heating. They should be mounted 8 feet from the floor and 3 to 5 feet behind workmen; otherwise, heat rays may be too intense.

Thermotube heaters (120-2,880 watts): These heaters consist of a heating element located inside a 2-inch aluminum tube. They are available in sizes of 60, 70, or 80 watts per foot length. They are designed for use in industry locations, such as poultry houses, and for supplemental heat in livestock barns.

Unit space heaters (3-20 kilowatts): These provide a safe, clean, and easily controlled source of heat for livestock buildings. Five-thousand-watt units have been used, but they require large-capacity transformers. When considering the use of high-capacity electric space heaters consult the power supplier, since a larger transformer, service entrance, and heavier wiring may be needed. The increased cost of higher energy rates and larger service equipment may make their use uneconomical.

Cost of Operation of Electrical Appliances

The following formula may be used to calculate the cost of operating an electrical appliance.

$$C = \frac{WR}{1000}$$

C = Cost, cents to operate 1 hour
W = Appliance electrical rating, watts
R = Cost of electrical energy, cents per kilowatt-hour

ELECTRICITY FOR LIGHT

Effective lighting of farmyards, livestock pens and barns, shops, and other areas where farmstead tasks are performed will increase worker efficiency by providing more pleasant surroundings, increase livestock performance, reduce accidents, and reduce incidence of vandalism. A variety of light sources is available, although cost restricts the use of certain types.

Mercury-Vapour Lighting

Mercury-vapour lighting is commonly used for dusk-to-dawn pole-mounted yard lights. Area-lighting mercury lamps are available in wattages from 125 to 1,000 watts. Mercury-vapour lamps are about 2½ times as efficient as regular incandescent lamps of the same wattage. Lamp life should also be extended from about 500 hours to 16,000-24,000 hours. Mercury-vapour lamps of 175 or 250 watts with suitable luminaires have been found satisfactory for yard and feedlot lighting. Where more than one unit is installed, individual photo controls on each unit will provide better continuity of service. Mercury-vapour lamps are not designed for use where they will be turned off and on frequently. They require a time lag of 15 seconds or more at startup and a much longer cool-down time between re-starts.

High-Pressure Sodium Lighting

High-pressure sodium lighting costs about 4 times as much as comparable size mercury-vapour lamps but has about 75 percent greater efficiency. Based on lumens per watt, sodium-vapour lights produce the lowest cost artificial lighting available today. Rated life of the lamp varies from 10,000 to 20,000 hours. The light produced is characterized by a "yellow-orange" illumination; however, newer developments have produced a "golden-white" color.

Fluorescent Lamps

Fluorescent lamps have long been used for low-cost, efficient lighting. These lamps give 3 to 4 times as much light per watt as incandescent lamps. For indoor or warm area lighting a variety of fluorescent lamps is available to produce various colors. For cold-weather use, lighting output is reduced and special low-temperature ballasts are required to ensure satisfactory starting.

Metal Halide Lamps

Metal halide lamps are new and are about 50 percent more efficient than mercury-vapour lighting. The initial cost is greater and the rated life is only about one-third as long, typically about 6,000 to 8,000 hours. A warmup period prior to starting and a cool-down period prior to restarting is required. Improvements in cost and life are necessary before this type of lighting becomes popular on farms.

Incandescent Lamps

Incandescent lamps are probably the most common lighting system in use; for high-level lighting, however, fluorescent lights are popular. There are about 16 lamps or bulb types in common use for both indoor and outdoor applications. Rough service (RS) lamps are also available for use in extension cords.

Good lighting systems should provide the proper quantity, quality, and color of light. In planning, the following should be considered: 1. Lighting level desired to perform specific tasks; 2. factors affecting the quality and color of light required; 3. the reflective factors of the ceilings and walls of rooms to be illuminated; 4. lamp location, output and type of luminaire or reflector used; 5. use of supplemental lighting; 6. care and maintenance required for the system. In Tables XI to XIII the recommended illumination levels for various farmstead tasks are shown.

TABLE XI
Recommended Illumination for Poultry Industry Facilities*

Areas and Visual Tasks	Minimum Ft-c on Task at Any Time	Explanation
Brooding, Production, and Laying Houses		
Feeding, inspection, and cleaning	20	Provided by a lighting circuit separate from the circuit used to stimulate production and growth.
Chart and records	30	Localized lighting is needed where charts and records are kept.
Thermometers, thermostats, and time clocks	50	Localized lighting is needed to accurately determine readings or setting.
Hatcheries		
General area and loading platform	20	Needed for operators to move about readily and safely. Needed for cleanliness of the general area.
Inside incubators	30	Portable or localized lighting is needed for inspection and cleaning inside incubators.
Dubbing station	150	Needed to prevent excessive cuts and injury. Supplemental light in addition to general lighting.
Sexing	1000	Needed for sex sorting of baby chicks. Supplemental light should be used in a closed area to prevent excessive brightness ratio between the task area and the immediate surrounding areas.
Egg Handling, Packing, and Shipping		
General cleanliness	50	General illumination is needed to keep area clean and to detect any unsanitary conditions.
Egg quality inspection	50	Needed to examine and grade eggs. Candling and other special grading equipment are used as separate devices for examining and grading eggs.
Loading platform, egg storage area, etc.	20	Needed for operator to move about readily and safely, and for safe operation and mechanical and loading equipment.
Egg Processing		
General lighting	70	Must meet the requirements of cleanliness for food preparation area. Includes liquid processing, pasteurizing, and freezing of raw eggs.
Fowl Processing Plant		
General (excluding killing and unloading area)	70	General lighting for cleanliness, inspection, and sanitation. Must meet requirements of food preparation areas.
Government inspection station and grading stations	100	Needed to detect diseases and blemishes. Vertical illumination is needed if birds are hanging.
Unloading and killing area	20	Needed to move about readily and safely.
Feed Storage		
Grain, feed rations	10	Needed to read labels, scales, and detect impurities and spoilage in feed.
Processing	10	Needed for operator to move about readily, and safely, read labels, scales, and equipment dials. Supplemental light would be needed if machine repairs are necessary.
Charts and records	30	If detailed records or charts are kept in the feed room, localized lighting in this area would be needed.

*ASAE Handbook 1971

TABLE XII
Recommended Illumination for Dairy Farms*

Areas and Visual Tasks	Minimum Ft-c on Task at Any Time	Explanation
Milking-operation area (milking parlor and stall barn)		
General	20	Required to determine cleanliness of cow, detect undesirable milk, handle milking equipment readily, and to detect dirt and foreign objects on the floor. Should be available at cow-edge of gutter, on floor.
Cow's udder	50	Supplemental to determine cleanliness of udder, to clean udder, to examine udder.

Milk-handling equipment and storage area (milk house or milk room)		
General	20	Required for operator to move about readily and safely, and to determine floor cleanliness.
Washing area	100	Necessary to detect dirt and other impurities on the milk-handling equipment. Supplementary, portable, ultra-violet fixture should be available in this area to aid in detecting milkstone on the equipment.
Bulk tank interior	100	Necessary to adequately inspect tank for cleanliness. Additional spots may be required to illuminate dipstick or scale.
Loading platform	20	Required for operator to move about readily and safely.
Feeding area (stall barn feed alley, pens, and loose-housing feed area)	20	Required for detecting foreign objects in grain, hay, or silage.
Feed-storage area, forage		
Haymow	3	Required for safety of the operator in moving about.
Hay inspection area	20	Required for detecting foreign objects in grain, hay, or silage.
Ladders and stairs	20	
Silo	3	Luminaires should be mounted at the top of the silo, near the ladder chute, for ease in cleaning and lamp replacement.
Silo room	20	Required for detecting foreign objects in grain, hay, or silage.
Feed-storage area, grain, and concentrate		
Grain bin	3	Required to inspect amount and condition of grain. When grain is suspected of being moldy, containing foreign objects, or otherwise contaminated, samples should be inspected under higher illumination levels.
Concentrate storage area	10	Required to read labels. Higher illumination levels are required for critical inspection for impurities and spoilage.
Feed processing area	10	Required for operator to move about readily and read labels, scales, and equipment dials. Additional light must be supplied by portable luminaires or daylighting, if machine repairs are necessary.
Livestock housing area (community, maternity, individual calf pens, and loose-housing holding and resting areas)	7	Required to observe the condition of the animals and to detect hazards to the livestock and operator. Portable, supplementary lighting units can be used to examine or treat individual animals when required.

*ASAE Handbook 1971

TABLE XIII

Recommended Illumination for General Areas Associated with Dairy and Poultry Facilities*

Areas and Visual Tasks	Minimum Ft-c on Task at Any Time	Explanation
Machine Storage		
Garage and machine shed	5	Needed to move machinery safely. Supplemental lighting is needed for minor equipment repair.
Farm Shop		
Active storage area	10	Needed for operator to move about readily and safely.
General shop	30	Machinery repair, rough sawing.
Rough bench-machine work	50	Painting, small parts, storage, ordinary sheet metal work, welding, medium bench work. May use localized lighting.
Medium bench-machine work	100	Fine woodworking, drill press, metal lathe, grinder. May use localized lighting.
Miscellaneous		
Farm office	70	
Restrooms	30	
Pumphouse	20	
Exterior		
General inactive areas	0.2	Recommended to discourage prowlers and predatory animals.
General active areas (paths, rough storage, barn lots)	1	Needed for operator to move about safely.
Service areas (fuel storage, shop, feed lots, building entrances)	3	Needed for servicing machinery.

*ASAE Handbook 1971

Electrical Controls

Table XIV illustrates the wide variety of electrical controls available for farm use, together with typical applications. In selecting controls for particular uses certain factors should be specified, the most important of which are: 1. The variable to be measured and the range within which it is to be controlled. 2. Accuracy in measurement. This is the degree of correctness with which an instrument measures a variable. Many farm applications do not require a high degree of accuracy, and inexpensive controls are frequently adequate. 3. Switching arrangement. The switch contacts on most controls can be arranged to either open or close upon the rise of the controlled variable. For example, heating requires a switch that will open with a rise in temperature; cooling requires one that will close with a temperature rise. 4. Current and voltage rating. The switch contacts that interrupt the current to the controlled machine must be heavy enough to carry the current as well as to withstand arcing when the circuit is broken. Both the current and voltage rating of the switch contacts are important. Frequently, ratings are given for "non-inductive" loads. These refer to heating and lighting loads that are relatively easy on the contacts. If contacts so rated are used to control electric motors, the rated capacity should be about one-third more than the capacity of the motors. 5. Control enclosures. A control should be selected with an enclosure suitable for the location in which it is to be installed. Dust-tight enclosures should be used in dusty places.

TABLE XIV

Control Units

Switch	Typical Applications
Single-pole single-throw (SPST)	Used to control a light, motor, heater, or other electrical device where on-off control is required. Used on 110V service.
Double-pole single-throw (DPST)	Used on 220V service.
Single-pole double-throw (SPDT), or three-way	Used to control a light from two locations.
Four-way switch	Used with three-way switches to control a light from three or more locations.
Double-pole double-throw (DPDT)	Used to isolate an emergency power source from a main electrical supply.
Motor-starting switch, manual	Used for manual control of a motor where overcurrent protection is desired.
Electromagnetic motor starter	Used to control an electric motor from one or more remote locations. Also required for sequence start-stop with or without a time delay.
Reversing drum switch	Used to reverse the direction of a split-phase or capacitor-start motor.
Pressure switch	Used to maintain the pressure of a fluid in a closed container between an upper and lower limit.
Environmental controls	
Thermostat (bellows gas-filled tube or bulb, or bimetallic element)	Used with a heater or ventilating fan for temperature control.
Humidistat (hair or lithium chloride element)	Used to control a humidifier or ventilating fan, but may not be satisfactory in dusty locations.
Level Controls	
Float-operated liquid-level control	Used for on-off control of a pump motor to maintain a liquid level between preset limits.
Floatless liquid-level control	Used to maintain a liquid level between limits where a float is undesirable, such as in a septic tank.
Bin level control (micro-switch or mercury-switch)	Used to control an auger to maintain the level of grain or processed feed in a bin.
Time Switches	
Preset timers (24-hour or 7-day)	Used to control a timed sequence of events, such as in a poultry house where lights are turned on or off with a dimming sequence.
Automatic re-set timer	Used where a timed event is to be repeated or to insert a time delay in a sequence of events.
Escape timer	Used to time single operations; requires re-setting each time it is used.

STANDBY POWER

The equipment required for standby electric power service includes a generator to produce alternating current, an engine to run the generator or a tractor P.T.O. power, and a transfer switch for control.

There are several types of generators available from complete automatic engine driven to P.T.O. powered units with manual transfer switches.

The capacity of the generator refers to the electric power output. Generators are rated as to power output in terms of kilowatts or watts (1 kilowatt equals 1,000 watts).

A tractor or stationary engine must develop a minimum of 2 horsepower for each 1,000 watts of capacity of the generator. For example, a 15,000-watt generator will require a 30-belt-horsepower tractor or stationary engine to drive it.

A transfer switch must be used in the standby electric power equipment installation to transfer the electric service from the power line to the generator. If a transfer switch is not used, a feedback of the generator voltage on power lines would endanger the life of the workman repairing the lines.

The size of generator needed for standby power services is determined on the basis of the full-load or part-load system. Under the full-load system, all electric equipment may be operated at the same time. Under the part-load system, only part of the electric equipment is operated at one time.

Before buying a standby unit, determine what loads are critical. These loads will include water and sewage systems, freezers, refrigerators, heating and ventilation systems, and lights. Buy a standby unit to handle these loads.

REFERENCES

Information and bulletins on the use of electric equipment in farm buildings may be obtained from the Agricultural Services Section of the Saskatchewan Power Corporation.

FARM BUILDINGS

PLANS FOR FARM BUILDINGS

The Canada Farm Building Plan Service has prepared several series of plans for various types of livestock and storage buildings. Catalogues of plans may be obtained from agricultural representatives, government agencies, and university departments. Some plans are also available from commercial firms through building supply dealers.

REFERENCES

Canada Department of Agriculture

Canada Farm Building Plan Service Catalogues of Plans. Separate catalogues available for each type of building, e.g., beef cattle, swine, grain storage, etc. (Available from agricultural representatives, Family Farm Improvement Branch, Saskatchewan Department of Agriculture, and the Extension Division, University of Saskatchewan, Saskatoon.) Detailed drawings of the plans shown in the catalogues may be obtained from the Family Farm Improvement Branch, Saskatchewan Department of Agriculture.

Saskatchewan Department of Agriculture

Beef Cattle Handling Facilities.
Buildings and Layouts for Beef Cattle.
Farm Workshop.
Farmstead Planning.
Swine Housing.

Other

Bulletins on the use of wood and plywood in farm buildings are published by the Canada Wood Council, 77 Metcalf Street, Ottawa, and the Council of Forest Industries, 1055 West Hastings Street, Vancouver.

FARM BUILDING CODE

The Canadian Code for Farm Buildings (1970) was prepared by agricultural engineers from across Canada under the auspices of the National Research Council. It is not a compulsory code unless adopted by a municipality. One portion of this document details basic standards for structural design, safety, and sanitation. The larger portion contains information on good practice and performance in the construction of farm buildings on such matters as space requirements, control of environment, and the use of building material. This document is a useful guide for both farmers and contractors. Farmers should consider specifying that buildings erected for them comply with the Canadian Code for Farm Buildings. Copies may be obtained for $1.50 from Association Committee of the National Building Code, National Research Council, Ottawa 7, Ontario.

MAKING QUALITY CONCRETE

Good-quality concrete can be made on the farm provided care is taken in proportioning and mixing.

Ready-mix concrete should be considered if available within reasonable distance. Recommended strengths of ready-mix concrete for various uses are shown in Table XV. As explained below, excess water weakens concrete. Where water must be added to ready-mix concrete at the time of delivery, the amount of water should be kept to the minimum necessary to produce a workable mix.

The ratio of water to cement controls the strength of concrete. Approximately 4 gallons of water should be used with each sack of cement and sufficient sand and gravel added to make a workable but not sloppy mix. More water and sand result in weaker concrete. For high-strength concrete, the sand and gravel must be clean and well graded, i.e., particle size should vary from fine through to coarse.

Table XV shows proportions for mixes made with sand and gravel separated. (Gravel, as distinct from sand, will not pass through a ¼-inch screen.) If pit-run material must be used, a larger amount of cement is required to obtain reasonable strength. The addition of coarse gravel to pit-run material is usually economical, since most pit-run gravel contains a high proportion of sand.

Concrete should be mixed for at least 1 minute after all the materials have been added; otherwise, weak spots and leakage can be expected. Concrete should be kept damp and free from frost for at least 7 days after placing, in order to gain reasonable strength. To hasten curing, calcium chloride may be used in a proportion of not more than 1¾ pounds per sack of cement. It should not be considered an antifreeze. Sulfate-resistant cement is recommended for all work where alkali attack may occur. Some protection from alkali may be obtained by waterproofing or by using high-quality concrete.

Concrete should be placed uniformly and tamped or vibrated to ensure a dense, uniform product, free of air pockets. Where possible, walls and foundations should be

placed in a continuous operation so as to avoid weak joints where fresh concrete joins concrete that has already set.

REFERENCES

The Portland Cement Association publishes several bulletins on the use of concrete in farm structures which are available from Saskatchewan cement suppliers (Canada Cement, Inland Cement Industries, and others).

TABLE XV

Suggested Mixes Made with Sand and Gravel Separated

	Kind of Work	
	Footings or foundation walls	Watertight basement walls, floors, steps, sidewalks, driveways, cisterns
Mix proportions		
Cement sacks	1	1
Sand (cu ft)	2 ½	1 ¾
Gravel (cu ft)	3 2/3	2 ¾
Imperial gallons of water to add to each 1-Sack (80 lb) batch		
Dry sand	4 ½	4
Moist sand (average)	4	3 ½
Wet sand	3 ¼	3
Maximum gravel size (in.)	1 ½	1
Materials needed for 1 cubic yard of concrete		
Cement (sacks)	5 ¾	7
Sand (cu ft)	13	13
Gravel (cu ft)	21	19 ½
Recommended strength of ready-mix concrete	2,000	3,000

It may be necessary to vary the relative amounts of sand and gravel slightly to obtain the required degrees of workability. The amount of water should not be varied beyond the limits recommended in the table.

FOUNDATIONS

The primary function of a foundation is to support the weight of the building without serious settlement or heaving. The size of foundation should, therefore, be designed according to the load to be carried and the load-bearing capacity of the soil. Where a conventional foundation wall and footing is used this can be accomplished by varying the width of the footing.

The load-bearing capacity of typical Saskatchewan soils 18 inches below grade may vary from 1,000 pounds per square foot for moist heavy clay to 4,000 pounds per square foot for dry sandy clay. Thus, although a footing width of 8 inches may be adequate for a light, single-storey structure on sandy soil, a width of 2 feet or more may be necessary for a two-storey barn with feed storage overhead on heavy clay soil. The bearing capacity of clay soils is considerably less when wet than when dry. It is, therefore, important to provide drainage around buildings to prevent settling and heaving. Shallow foundations are more likely to be affected by soil moisture changes. Footings should be placed at least 18 inches below grade level to minimize the effects of moisture and to discourage the entry of rodents. Interior footings for load-bearing posts are usually made too small compared with the wall footings; interior posts frequently carry most of the second floor and roof weight.

Masonry buildings are more susceptible than frame buildings to damage by settling, so better foundations are required for them. A concrete pile and grade beam type of foundation may be more economical than a conventional foundation wall with a footing 4 or 5 feet deep. In this type of construction, concrete piles 8 to 10 inches in diameter and 10 feet deep are located at approximately 8-foot intervals. They support a grade beam which is usually 8 inches wide and 18 to 24 inches deep. Commercial reinforcing steel is required in piles and grade beam to obtain a good bond with the concrete. The use of reinforcing steel in all types of concrete foundations is recommended.

For small buildings and favorable soil conditions, a combined floor slab and foundation may be used. The floor slab is thickened to approximately 16 inches under outside walls and bearing partitions. Reinforcing with light rods or wire mesh is recommended. For curved rafter and rigid frame-type buildings the foundation should be designed to carry outward thrust. Where pole construction is used, the poles serve as the foundation. With high buildings or long spans, the vertical and horizontal load-carrying capacity of the poles can be increased by placing them in oversized holes and backfilling with concrete. The diameter of the holes should be at least 8 inches greater than that of the poles to provide an effective thickness of concrete. Post-pier foundations consisting of 6-inch pressure-treated posts set 4 to 5 feet apart and capped with a box sill of treated plank or plywood should be considered. This construction is somewhat lower in cost and requires considerably less labor than other types of foundation. It can be insulated readily for heated animal buildings.

FLOORS

Concrete floors are suitable for all types of farm buildings. When used in grain storage, 6-mil plastic film or an asphalt layer should be provided underneath to prevent the rise of moisture. Concrete floors can be made more comfortable by insulating along the outside edge with a waterproof material such as foamed plastic or foamed glass. This should be placed under the outer 2 feet of the floor and between the floor and foundation to prevent the escape of heat in this region. Slatted floors are commonly used to simplify manure handling in larger swine operations. Removable slatted floor sections of precast reinforced concrete may be obtained. These are recommended in preference to wooden slats, which wear rapidly.

Wood floors may be used in horse barns. But, because of problems with disease and rot, they are not recommended for other livestock buildings.

METHODS OF FRAMING

Light Timber Framing

Light timber framing, commonly consisting of studs and rafters 16 to 24 inches apart, may require angle bracing to prevent distortion due to wind and other loads. Sheathing applied diagonally and sheet materials such as plywood provide excellent rigidity without additional bracing. Braces of 2-inch material cut to fit between studs are relatively ineffective, but continuous braces of 1-inch material let into notches in the face of the studs are relatively good.

Pole Frame

In this method, pressure-treated poles 12 to 15 feet apart are used as the basic structural element. Rafters or roof trusses are supported by planks spiked or bolted to the tops of the poles. Wall sheathing is attached to nailing girts placed horizontally. Knee and corner braces provide stiffness. Since no stud space is available for insulation, this type of construction is best suited to buildings such as garages, machine sheds, and beef cattle shelters.

Roof Trusses

These can be used to advantage where post-free spans greater than 20 feet are desired. The trusses must be properly designed and constructed. Designs may be obtained from the Family Farm Improvement Branch, Regina, and from various lumber suppliers.

Curved Rafters

Rafters for curved roofs may be sawn or bent to shape. Bent rafters usually consist of several plies of 1 by 3 or 1 by 4 bent to the desired shape in a form and fastened together

with nails, bolts, glue, or a combination of these. The use of glue is strongly recommended. Casein glue is simple to use and satisfactory if not exposed to excessive moisture. Resorcinal resin glue will withstand more severe moisture conditions but is not so simple to use. For a building 40 feet wide with bent rafters at 2-foot spacing, 7 ply of 1 by 3 is recommended.

The Gambrel Roof

This is now seldom used on barns but it is economical for machine sheds and grain storage. Joints between rafters must be well made and attachment to foundations should be secure.

Rigid Frame

These buildings are similar to curved-rafter buildings in shape and in application but they have the advantage of using standard-size material.

Circular Plywood

This contruction is economical for large grain storages. Vertical joints between sheets must be very well made, using glue and nails. Steel bands are frequently used to provide additional strength.

Steel Buildings

Steel buildings are being sold for farm use in a variety of sizes, types, and qualities. Not all of those offered for sale have proven satisfactory. The reputation of the manufacturer and dealer should be thoroughly investigated before an agreement is signed or a downpayment made. Good-quality steel buildings, properly erected, will have a long life with minimum maintenance, making them competitive on an annual cost basis with some other types of construction which are cheaper initially.

Roofing

Table XVI presents characteristics of some common types of roofing materials.

TABLE XVI

Some Common Types of Roofing Materials

E: excellent; G: good; F: fair; P: poor.

Material	Ease of Application	Probable Life	Relative Upkeep	Decking Required	Minimum Recommended Slope (in./ft)
Wood shingles	F	G	F	Slatted	6
Asphalt shingles	G	F	G	Solid	4
Asphalt roll—					
6-in. lap	G	F	F	Solid	3
18-in. lap	F	F	G	Solid	1
Built-up	P	G	F	Solid	1½
Galvanized	G	G	E	2-in. material 24-in. (on centre)	3
2-in. corrugations					
Aluminum*	G	F	G	2-in. material	
2-in. corrugations				16-in. (on centre)	3 **
Asbestos cement	F	E	E	Solid	6
Plywood***	G	F	P	None	2

*Flat metal sheets are not recommended. A variety of corrugation styles is available.
**Solid decking will reduce the probability of damage to aluminum by hailstones.
***Plywood exposed to the weather should be exterior grade, made with waterproof glue.

INSULATION AND VENTILATION

Condensation

When warm, moist air meets a cold surface some of the moisture condenses, either as liquid or as frost depending on the temperature of the surface. Condensation may be controlled by making the surface warmer (insulating) or by reducing the relative humidity of the air (ventilating). Heating may be necessary to permit ventilation in cold weather. A vapor barrier must be provided on the warm side of insulation to prevent moisture from condensing within the wall. The vapor barrier may consist of plastic film or suitable paint films. Condensation problems within walls may also be minimized by using outside coverings that allow moisture to escape.

Insulation

Table XVII indicates the properties of a number of types of insulation.

TABLE XVII

Properties of a Number of Types of Insulation

E: excellent; G: good; F: fair; P: poor

	Mineral Wool	Vermiculite	Shavings	Foamed Polystyrene
Resistance to heat Flow per inch thickness	batts 3.7 fill 3.3	2.1	2.2	3.7
Method of installing	batts, blankets, or loose fill	blown or poured	manual and tamped	sheets
Resistance to settling*	batts— G loose fill— F	E	F	E
Resistance to rot	E	E**	P	E
Resistance to fire	E	E	walls— G ceilings— P	F
Resistance to insect and rodent attack	E	E	F	G

*The tendency of blown-in insulation to settle depends primarily on the operator of the blowing machine.
**Although vermiculite itself will not rot, its tendency to absorb and hold moisture may cause rotting of adjacent wood.

Wood fibreboard has good resistance to heat flow per inch of thickness but thicknesses available are 1 inch and less. Fuel savings will justify the use of 3 to 4 inches of insulation in house walls and up to 6 inches on ceilings, depending on the price of fuel. In livestock buildings, which require some measure of temperature control, at least 4 inches of insulation is needed to permit satisfactory ventilation. Vegetable storages may require 6 inches of insulation to maintain indoor humidities without condensation.

Ventilation and Heating

Livestock buildings need to be ventilated to provide fresh air and to remove moisture in winter and heat in summer. If ventilation is adequate for moisture and temperature control there will usually be enough fresh air to supply oxygen. The amount of ventilation needed to remove moisture given off by livestock is least in cold weather and greatest in mild weather, as shown in Table XVIII. Air flow in flues or ducts through the roof is greater in cold weather than in warm weather. As a result, flue systems are not entirely satisfactory. Mechanical fans make controlled ventilation possible and are recommended for all but very small enterprises.

TABLE XVIII

Ventilating Fan Capacities, Cu Ft per Minute (cfm)

Type of Livestock	Outdoor Temperature °F.			
	-30	0	30	85
Dairy, per 100-lb cow	25	35	60	300
Swine, per 125-lb pig	4	6	15	60
per sow and litter	12	20	45	250
per 40-lb weanling	2	4	8	30
Poultry, per 100 – 3½-lb birds	45	55	110	600

For a fan ventilation system to operate properly, the fans must be the correct size and the inlets and outlets

must be arranged to ensure circulation in all parts of the building without direct drafts on the livestock. Good results will be obtained where a small fan, running continuously, supplies the minimum air quantity and a larger fan, controlled by thermostat, provides additional ventilation in mild weather. Two-speed fans can be used to give a limited range of capacity. Variable-speed fans will deliver air quantities ranging from zero to their maximum rated capacity, making it possible to control indoor temperatures within very narrow limits. To reduce the possibility of moisture on fan blades freezing to the casing and causing motors to burn out, exhaust hoods should be provided, which extend at least 2 inches below the fan opening. Where exhaust fans are used, inlet for fresh air must be provided. Fresh air drawn from an attic space will usually be a few degrees warmer than outdoor air. Air from the attic can enter the occupied space through long, narrow slots. In buildings up to 36 feet wide, fans may be located along one wall. In buildings more than 36 feet wide, fans should be located in both walls. Where slot inlets from the attic are used, one fan should run continuously to prevent moist air from moving into the attic from the barn when fans are not operating. For summer cooling, fresh air should be drawn directly from outdoors rather than from the attic. Removable, insulated wall panels can be used for this purpose. These panels can also be used as an emergency source of fresh air in case of a power failure.

To remove moisture by ventilation without excessively reducing the inside temperature, the walls and ceilings must be well insulated. Storm windows should also be provided. Windows in livestock buildings should be kept to a minimum and may be eliminated altogether to conserve heat and reduce construction costs.

In sub-zero weather it may not be possible to keep the building both warm and dry if animals are the only source of heat. Supplemental heat may, therefore, be required in swine and poultry buildings. Although supplemental heat may be needed for only a few weeks each winter, the fuel cost may be more than repaid by the feed saved and by increased production. Warm-air furnaces, unit heaters, or hot-water pipes in the floor may be used. Heating units connected to chimneys or vents should be in separate rooms to prevent backdrafts in the chimney when exhaust fans are operating. An opening from outdoors into the furnace or boiler room must be provided to permit air to enter. An opening approximately 10 inches square will be sufficient for average-size furnaces. The partition between the furnace room and the rest of the building should be reasonably airtight and should be of fire-resistant construction. Table XIX shows the comparative cost of heating with different fuels.

TABLE XIX

Cost of Heating

Fuel	Cost per unit	Efficiency assumed	Cost per million btu of heat received
Oil	18c per gal	Pot-type burner 50%	$2.15
		Gun-type burner 60%	$1.80
Liquefied propane gas	$9 per bottle	70%	$6.40
	18c per gal (bulk price)	70%	$2.35
Natural gas	65c per m cu ft	70%	$0.95
	80c per m cu ft	70%	$1.15
Electricity	1½c per kwh	100%	$4.40
	1c per kwh	100%	$2.90

Note: Local fuel prices will vary from the above, so costs in the table should be adjusted accordingly. Efficiencies assumed are representative for space heating.

WOOD PRESERVATION

Decay of wood is caused by fungi whose innumerable microscopic threads digest the wood as they grow through it. Most kinds of fungi cannot grow in well-seasoned, dry wood or in wood that contains preservative. Thus, wood in properly constructed buildings can remain sound indefinitely. Ideal conditions for decay are provided where wood is in direct contact with the ground or in moist unventilated places such as under many basementless buildings.

Whenever wood is to be used in moist places or in contact with the ground it should be treated with a preservative which is poisonous to fungi. This will protect it from decay for many years. A preservative provides direct protection only to wood into which it has penetrated. A treated surface layer thus acts as a barrier which protects the untreated interior wood from attack by fungi from the outside. If an opening is made through this protective barrier, fungi may gain access to the untreated interior wood through this opening. Therefore, if it is necessary to make cuts through the treated surface, or if shrinkage cracks occur after the wood is treated, these exposed surfaces should be swabbed generously with preservative.

Decay of Floors and Basement Timbers

It is much simpler to prevent decay than to get rid of it once it has attacked a building. Sills or other wooden parts should never be placed in contact with the ground, but only on stone or concrete foundations or piers. Under buildings without basements a crawl space of not less than 8 to 12 inches should be left above the ground, and large openings should be left in the foundation for ventilation. Completely covering the ground under such buildings with polythene film or heavy asphalt roll roofing greatly helps to prevent decay by preventing ground moisture from causing a damp atmosphere. Only sound, well-seasoned wood should be used under buildings. The under surface of floor boards, and all surfaces of joists, sills, and other wood parts beneath basementless buildings should be treated with preservative before they are fastened in place. A solution of 6 ounces of sodium fluoride per gallon of water is recommended. This should be applied generously, and should be flooded into all cracks and crevices. At least two applications are recommended.

Decay of floors and basement timbers is sometimes caused by a certain kind of fungus named Merulius which can transport moisture for its own needs in much the same manner as a vine, and which therefore can grow in dry wood.

Many instances are known where Merulius that was present in wood buried in the ground has gained entrance through badly constructed concrete basement walls and has caused such serious decay in floors, joists, and partitions that these parts have had to be completely replaced to save the house from collapse. This has occurred in many modern expensive houses, but it is most likely to occur in buildings without basements where proper ventilation has not been provided.

After Merulius decay has taken hold in a basement it cannot be stopped by applying preservative alone. The only remedy is to remove the affected boards and timbers, and replace with sound, well-seasoned, treated wood. If it is not possible to remove entire boards, joists, etc., when only partly rotted, the rotted parts may be cut out, but the cut must be made in perfectly sound wood as far as possible beyond the last trace of decay. It is important to treat these surfaces thoroughly before making joins, and all surfaces enclosing the entire basement space (including soil) should be thoroughly saturated with preservative. All of the removed wood and all fragments and debris under the repaired building should be removed and burned immediately.

Treating Fenceposts

Fenceposts are most effectively treated with preservative under pressure. This can be done only at commercial treating plants. These plants are becoming more common throughout the country, and their services should be investigated before embarking on a "do-it-yourself" treating job.

Home treatment, however, is worthwhile, and can be done simply and cheaply on any farm. It is most important to treat butts up to about 8 inches above ground level. For added protection the tops may be given a light treatment, especially if the posts are of a non-durable species such as poplar.

1. **Treating Dry Posts**—The posts must be peeled, well-seasoned, and dry. It is important to remove the thin strips of inner bark that sometimes remain after peeling.

In the "cold soaking" butt treatment the dry posts are stood for one or more days in a tank (such as a steel oil drum) of unheated preservative to a depth of about 8 inches above ground line. Good preservatives are: a. Creosote, 50 percent solution; b. penta (pentachlorophenol) 5 percent solution; c. copper naphthenate 2 percent solution. These solutions can be made with diesel or fuel oil, with which waste crankcase oil may be mixed.

The preservative penetrates better if the mixture is heated by setting the tank on a brick or stone fireplace. The oil-type preservatives are flammable and precautions should be taken against accidents with fire. Still better penetration is obtained if, after 4 hours or longer in the hot mixture, the posts are transferred for a few hours to a tank of cold mixture, or if they are left in the hot mixture overnight to cool.

2. **Treating Green Posts** (Sap Displacement Method)—In this method, freshly cut and peeled green posts are stood upright in a water solution of chemical. Bluestone (copper sulphate) at 16 pounds to 10 gallons of water is the most commonly used. A solution of chromated zinc chloride (1 gallon in 8½ gallons water) provides more permanent protection, but this chemical is not so readily available. Bluestone is corrosive to steel, so wooden or concrete tanks must be used with it.

Soaking should last 4 days or more, depending on weather conditions. When bluestone is used, its progress up the posts can be observed and treatment stopped when color nears the tops. The posts should then be allowed to season slowly in the shade before use. If deep shrinkage cracks develop, the posts should be given a second dip. Tests in the United States indicate that the bluestone treatment can be made more permanent if the posts are first soaked for 2 days in a solution of one-half pound of sodium fluoride per gallon of water.

All chemicals should be considered poisonous if swallowed by animals or humans.

REFERENCES

Fencepost Preservation. Family Farm Improvement Branch. Saskatchewan Department of Agriculture.

The Preservative Treatment of Fenceposts by Non-Pressure Processes. Publ. 107, Department of Forestry.

Wood Preservation Around the Home and Farm. Publ. 1117. Department of Forestry.

FARM WATER AND SEWAGE

Few major streams and rivers traverse the Prairies and these do not provide farmers with ready access to any sizeable dependable water supply. Farm water supplies must usually be obtained from wells, or surface storage facilities. The Saskatchewan Water Resources Commission (S.W.R.C.) regulates the development of these supplies under provisions of The Water Rights Act and The Groundwater Conservation Act. The Prairie Farm Rehabilitation Act (P.F.R.A.) provides technical and financial assistance in the planning, design, and construction of surface water-storage structures. The Family Farm Improvement Branch, Saskatchewan Department of Agriculture (F.F.I.B., S.D.A.), gives technical and financial assistance on the design and installation of farm water and sewage facilities.

WATER RIGHTS

All surface and underground water in Saskatchewan is owned by the Crown and administered by S.W.R.C. Any person who desires to use this water must apply to the Commission for a water right or licence. The following exceptions do not require a licence: a. A well to be used for domestic purposes; b. a dugout to be used for domestic purposes; c. the use of a pump to fill tanks, cisterns, or dugouts for domestic purposes, provided no works are built to divert or store the natural flow of water.

"Domestic purposes" means household and sanitary purposes, the watering of stock, the spraying of crops, the watering of non-commercial lawns and gardens adjoining private residences, but does not include the sale or barter for such purposes or use for intensive livestock feedlot operations.

To obtain a licence or water right, a person must make an application to the Water Rights Branch, S.W.R.C., consisting of a properly completed Memorial, plans on linen of the proposed project, and a licence fee. These documents are then examined by the Commission to determine that there is sufficient water available; that the applicant owns, controls, or has sanctions in writing for all of the lands affected by the project; that beneficial use will be made of the water and that the project does not interfere with the water supply of other persons. When all of these conditions have been met, an authorization to construct the works is granted to the applicant. Upon completion of the project, it is inspected, and if it is found to conform to the plans, a licence is issued.

Water licences are issued to a specific person, granting him the right to use a definite quantity of water annually. A licence is not appurtenant to the land, and when land changes ownership it is the duty of the new owner to apply to the Commission for a transfer of licence or else breach the works so they no longer divert or use water.

Additional information may be obtained from Water Rights Branch, S.W.R.C., S.P.C. Building, Regina.

FARM WATER SUPPLY

Wells

Wells are generally the best source of potable (drinkable) water, and when properly constructed, there is less possibility of contamination. Well water usually requires little or no treatment.

Before drilling a well, one should obtain information on the quality and occurrence of ground water by examining

neighboring wells. The Saskatchewan Research Council has conducted an extensive drilling program to study geology and ground water systems throughout the province. Maps have been prepared which outline major water-bearing formations and contain information as to the maximum depth at which potable water may be found. Additional information on ground water may be obtained without charge from the F.F.I.B., S.D.A., and the S.W.R.C. The Commission has information on approximately 90,000 wells drilled in the province, in addition to reports prepared by the Saskatchewan Research Council. Upon request (please include land location) the Commission will prepare a water probability report indicating the probable quantity, quality, and depth at which water may be found in most districts throughout the settled area of the province.

The selection of a well-drilling contractor is most important. (See reference 1.) It is generally recommended that a local driller with electric logging equipment for test drilling and a reputation for constructing high-yielding, sand-free wells be considered. S.W.R.C. requires all water-well drilling machines to have a registration plate for the current year attached to them. This registration plate does not guarantee the competency or integrity of the operator. The customer should be satisfied with the driller's ability before contracting with him.

Separate written contracts are recommended for test drilling and for well construction. The test-drilling contract should specify the price per foot for drilling and electric logging. The well-drilling contract should specify the minimum yield and quality which can be considered a well; the price per foot of cased well; size, type, and wall thickness of the well casing (minimum of 5-inch inside diameter casing); cost of supplying and installing a well screen; cost of well development; provision for pump testing (minimum of 6 hours recommended); and a guarantee on workmanship and materials.

The well screen is one of the most important parts of a well. Its purpose is to permit a high yield of water into the well and to prevent sand from entering with it. Recent research in this province indicates that in nearly all farm wells, a number 10 (0.010 inch) slot screen is satisfactory for fine sand. Perforated or slotted casing is not recommended as a substitute for a well screen. Before using water from a new well, a chemical analysis is recommended to determine the water's suitability for human and livestock consumption.

Where quicksand problems are encountered in larger diameter wells, a smaller diameter jetting-type screen may be installed to increase water yield and reduce or eliminate sand problems. (See reference 2.)

Costs for test drilling and well construction are partially covered by a grant under the farm water and sewage program of F.F.I.B., S.D.A. The grant is based on 15 percent of all outdoor materials and construction costs to a maximum of $300 per farm dwelling.

Dugouts

Dugouts are the most common storage structure for surface water on prairie farms. A dugout should be located to catch the runoff from at least 50 acres of land. This drainage area can be reduced by using trees, snow fences, etc., to collect snow on the dugout watershed. No deciduous trees (those which lose their leaves) should be planted within 50 feet of the dugout.

Financial assistance is provided by P.F.R.A. (see reference 3) and F.F.I.B., S.D.A. To qualify for maximum assistance under P.F.R.A., a dugout should be 14 feet deep, 70 feet wide, and 200 feet long, with end slopes of 4 to 1 and side slopes of 1½ to 1. This requires the excavation of about 4,143 cubic yards of earth and would provide storage of approximately 650,000 gallons of water. An additional grant is available from F.F.I.B., S.D.A. on dugouts of 7,000 cubic yards or larger. On larger dugouts, the above end and side slopes should not be exceeded. Dugouts with greater depth provide more efficient storage.

A large dugout is recommended if a water-pressure system is to be installed, since water use tends to increase and a larger reserve supply is required.

Before starting a dugout, test holes should be dug at the corners and in the centre of the proposed location to determine the soil type. Where the soil is very porous but the site otherwise good, it may be necessary to line the dugout with clay or with a plastic or butyl rubber liner to prevent excessive water loss.

Dugouts should be located to prevent contamination by runoff from farms and livestock yards, garbage, and sewage, and fenced to keep out livestock. Grassing water runways and watershed will reduce silting in the dugout, but regular maintenance is required. (See reference 4.)

Dams

Dams are also used for storing surface water on the prairie farm. Careful surveying, planning, design, and construction are necessary. On application, P.F.R.A. will provide free surveys and plans that comply with The Water Rights Act. P.F.R.A. will also provide financial assistance for the construction of projects which have been approved by the Water Rights Branch, S.W.R.C.

Water Treatment

Surface water should be filtered and chlorinated before it is used for human consumption. (See reference 4.) Floating inlet pipes are recommended to withdraw the highest quality water from near the surface of the reservoir. The inlet must be lowered in winter to a level below the anticipated ice cover. Chlorinators and pressure filters installed in the farm home are considered to be more effective and serviceable than filter trenches.

To control algae in a reservoir, add 1 pound of copper sulphate for each 100,000 gallons of water every few weeks during summer, starting in May. See Tables XX and XXI. The copper sulphate dissolves quickly when pulled through the water in a cloth bag. It is necessary to distribute the chemical as evenly as possible over the entire surface area.

TABLE XX

Weight of Copper Sulphate Required to Treat a 165 ft x 65 ft x 14 ft Dugout

Water Depth	Approximate Water Volume	Wt. Copper Sulphate
14 ft	450,000 gal	4½ lb
12 ft	330,000 gal	3 lb
10 ft	233,000 gal	2½ lb
8 ft	155,000 gal	1½ lb

TABLE XXI

Weight of Copper Sulphate Required to Treat a 200 ft x 70 ft x 14 ft Dugout

Water Depth	Approximate Water Volume	Wt. Copper Sulphate
14 ft	652,000 gal	6½ lb
12 ft	491,000 gal	5 lb
10 ft	357,000 gal	3½ lb
8 ft	246,000 gal	2½ lb

When water weeds are a problem in a dugout or dam, diquat "Reglone A" may be substituted for copper sulphate for the first treatment during the early summer to control most water weeds and algae. A 24-hour waiting period should be observed, during which there should be no consumption after treatment with diquat. Manufacturers' recommendations should be closely followed. If the water is not wholly contained on the owner's land or discharges from it, a permit is required from S.W.R.C. before treatment.

Both surface water and ground water may be treated for turbidity (cloudiness due to suspended silt or clay), bacteria, hardness, iron, taste, and odor. The method of treatment and the equipment costs vary between farms and a laboratory analysis of the water should be obtained to determine the treatment and equipment required. Water tests and technical advice are available from F.F.I.B., S.D.A.

Tests for chemical and bacterial impurities and suitability for drinking are done by the Provincial Laboratory, Department of Public Health, Regina. Sterilized water-sample containers and information on water quality may be obtained from any Regional Health Office in Saskatchewan or from the Provincial Laboratory. Bacterial tests should be done only after a well is completed and thoroughly pumped. Chemical (but not bacterial) tests are made at the F.F.I.B. field and Regina office and at the Civil Engineering Department, University of Saskatchewan, Saskatoon.

Table XXII provides a rough classification of water for drinking based on total dissolved solids (T.D.S.). Water with high T.D.S. should be avoided. The concentration of individual chemicals such as sulphates or nitrates may be critical. Infants and visitors are more susceptible to high concentrations of chemicals. Tolerances by individuals may greatly exceed recommendations. Sows and young pigs are not tolerant to high concentration of T.D.S.

TABLE XXII

Classification of Water For Drinking

Total Dissolved Solids (parts per million)	
For use by	Maximum Usually Acceptable
Humans	3,000
Livestock	5,000

PRESSURE SYSTEMS (See Fig. 3)

A farm pressure system consists of a pump, a pressure tank, and related accessories. Where the suction lift, including friction loss in the pipe is less than 20 feet (a total lift of 15 feet is usually considered a safer maximum), a centrifugal jet or reciprocating-type, shallow well pump is usually satisfactory. For depths in excess of 20 feet, a deep-well jet pump is generally used. Increasing use is being made of submersible pumps, which are suited to either shallow or deep wells, provided the water is relatively free of sand.

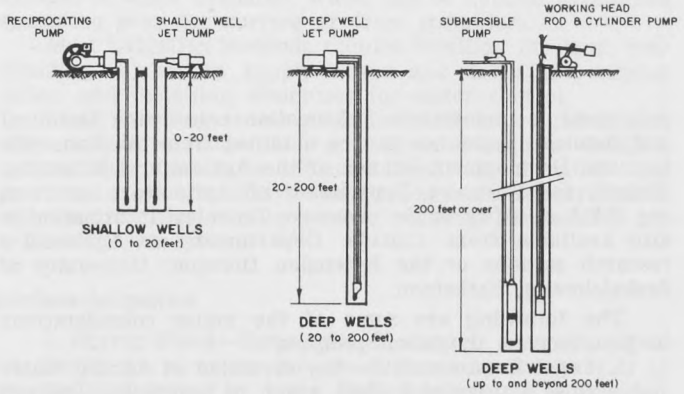


Fig. 3—Types of water pumps
(Shown in relation to suction lift)

When selecting a pressure system, the following should be considered. (See reference 5.) 1. Water requirements and availability; 2. depth of well; 3. size of well casing (inside diameter); 4. horizontal distance between pump and water source; 5. elevation difference between pump, well head, and pumping water level at source.

WATER DISTRIBUTION SYSTEMS

Polyethylene plastic pipe is used for water distribution systems and for drop pipes in wells with jet and reciprocating pumps. Only plastic pipe with the label "C.S.A. CERTIFIED" should be used to assure quality. Required pipe diameter and pressure rating depend on the rate of water flow, the water pressure, and the length of the pipe. Increased future needs should be considered when sizing pipes. For farm water systems, the general recommendation is to use a minimum of "Series 75" (75 psi) C.S.A. certified polyethylene plastic pipe. Water lines should be buried at least 8 feet deep (10 feet under roadways, in sand, or in northern districts).

Frost-proof yard hydrants (see reference 6) may be installed for irrigating, watering livestock, filling pails, washing vehicles, fire fighting, etc. Frost-proof, automatic livestock waterers (see reference 7) provide a constant, year-round supply. They are electrically heated and are available in a variety of sizes for cattle, sheep, and hogs. Depending on the size, one waterer may supply up to 100 head. Electrically heated waterers should be wired and grounded according to the electrical code to avoid electrocuting livestock. All other electrical wiring should meet the specifications of the electrical code. (See reference 8.)

SEWAGE DISPOSAL (See Figs. 4 and 5)

Plumbing (see reference 9) can be installed in the farm home by most farmers with the aid of diagrams and a list of materials provided by an F.F.I.B. technician. On application to the district agricultural representative, short courses in plumbing may be provided by the Department of Education. A permit must be obtained from the Department of Public Health for the installation of a plumbing system.

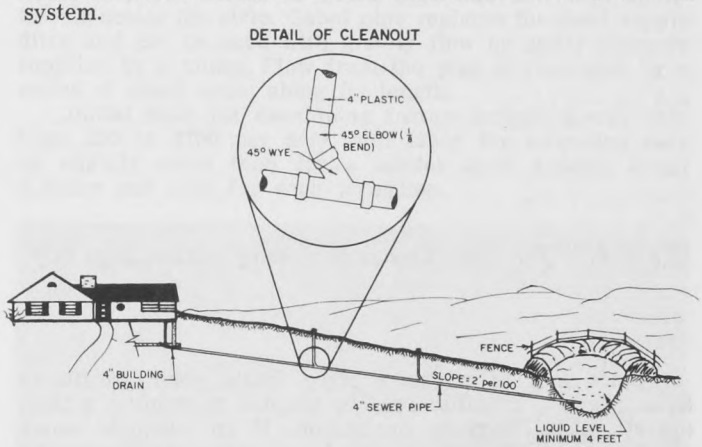


Fig. 4—Typical sewage disposal installation

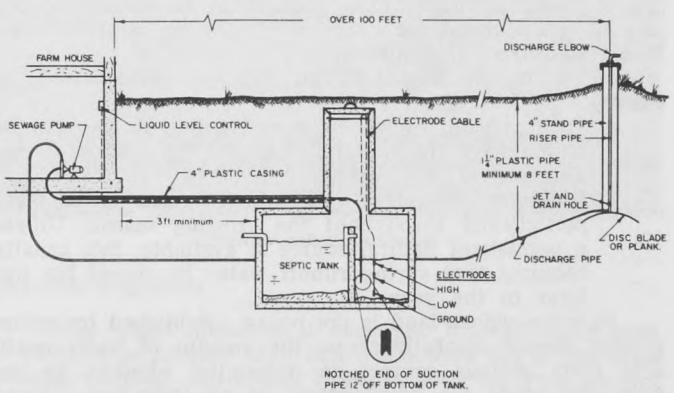


Fig. 5—Typical installation of open-discharge jet system

A sewage lagoon is the least expensive sewage disposal system. (See reference 10.) The farm supply should be sufficient to maintain 4 feet of liquid in a lagoon. The soil of

the lagoon site should be impervious or made impervious by lining. Lagoons are usually located about 200 feet from the house. Ground elevation at the house should be 8 feet or more above the lagoon (to provide drainage pipe slope of 2 feet per 100 feet) for gravity flow of sewage. (See Fig. 4.)

A septic tank (see reference 10) is required for all types of sewage disposal systems except where using a lagoon. Septic tanks should be resistant to corrosion and strong enough to withstand earth pressure. A septic tank must have a minimum working capacity of 400 gallons, which is usually adequate for up to eight persons. Effluent from septic tanks is normally disposed by open discharge. (See Fig. 5.) Bell syphons and disposal fields are not recommended.

MAINTENANCE OF WATER AND SEWAGE SYSTEMS

Pressure systems should be checked often to see that the air-volume control and pressure switch are functioning, that pump seals are not leaking excessively, and oil and grease are being provided according to manufacturers' recommendations. Check frost-free hydrants every fall to see that the shutoff valves are seating properly to avoid leakage. Livestock waterers should be cleaned frequently and thermostat settings and float levels checked and adjusted every fall. Wells and water systems should be shock chlorinated yearly to control iron bacteria, tastes, and odors. (See reference 11.)

Clean out the septic tank when sludge accumulation exceeds 1 foot and clean the electrodes every fall. Sewer gas is poisonous and explosive. Caution is necessary when servicing or cleaning septic tanks. (See reference 12.) Commercial cleaning services are available and recommended.

Short courses on maintenance of farm water and sewage systems may be provided by F.F.I.B. personnel on application through the district agricultural representative.

REFERENCES

1. *Well Drilling—A Guide for Farmers.* Publ. T32.
2. *Sand-Free Water From Quicksand Wells.* Publ. T35.
3. *Water Development Under the P.F.R.A. Program* (available from P.F.R.A., Regina, and all field offices).*
4. *Using Dugout Water.* Publ. T19.
5. *Water Pressure Systems-Selection and Installation.* Publ. T20.
6. *Frost-Free Hydrants.* Publ. T5.
7. *Automatic Livestock Waterers.* Publ. T6.
8. *Electrical Information for Farm Water and Sewage Installations.* Publ. T24.
9. *Farm House Plumbing.* Publ. T7.
10. *Farm Home Sewage Disposal in Saskatchewan.* Publ. T9.
11. *Iron Bacteria in Rural Water Supplies.* Publ. WS1.
12. *Safety Pointers.* Publ. T2.
13. FF10 List of publications available from F.F.I.B.
14. *Standard Water Quality Criteria,* S.W.R.C., SPC Building, Regina.*

*All publications except these are published by Family Farm Improvement Branch, Saskatchewan Department of Agriculture, and available from all Department field offices.

IRRIGATION (See illustrations, color section, page 84.)

Since lack of moisture often limits plant growth in Saskatchewan, irrigation may be adopted to stabilize a farm operation and increase production. If an adequate water supply is available, the limiting factors which will determine the feasibility of irrigating are topography and soils. Before developing a water source for irrigation purposes, authorization for the construction of works and the subsequent licence to use water must be received from the Saskatchewan Water Resources Commission.

Irrigation in Saskatchewan may be categorized as follows:

a. Spring flood, by which runoff water is diverted or temporarily impounded, usually to provide one watering in the spring.
b. Intensive irrigation, by which water is applied periodically throughout the growing season. Unless a permanent natural source is available, this usually requires that spring runoff water be stored for use later in the year.

Farmers whose land is not on an established irrigation project should carefully assess the amount of water available from various sources to determine whether an opportunity exists for development of an irrigation scheme on their lands.

IRRIGATION PLANNING

Technical assistance should be obtained during the early planning stage and before any construction or development is undertaken. Information concerning technical and financial assistance can be obtained from the Conservation and Development Branch or the Agricultural Extension Branch, Saskatchewan Department of Agriculture, or from any P.F.R.A. office in the province. Technical information is also available from Canada Department of Agriculture research stations or the Extension Division, University of Saskatchewan, Saskatoon.

The following are some of the major considerations in planning an irrigation program:

a. Legal Requirements—Any diversion of natural water flow, storage of surface water, or pumping of ground water for irrigation requires a water right or licence from Saskatchewan Water Resources Commission. Details of procedure can be obtained from Conservation and Development Branch or P.F.R.A. (See Water Rights, page 33.)
b. Water Quality—Irrigation requires substantially larger quantities of water than are necessary for a domestic supply or stockwatering purposes. Because of this, the measurement is usually in terms of acre feet rather than gallons. (See Water Application and Irrigation Practices.)
c. Water Quality—An analysis of the water being considered for irrigation use should be obtained to determine its actual salt content. Good irrigation water should be low in sodium and should contain less than 500 parts per million of dissolved solids. Continuous use of water with high salt content may

result in a buildup of salts in the soils, with a resultant deterioration of the soil and reduction in productivity.

d. Topography—The topography of the land and the elevation of the water source in relation to the land being irrigated will determine the method of distributing the water and the associated cost. If the source of water is at a higher elevation than the land to be irrigated, the water can be conveyed most economically by gravity. If pumping is required to lift the water to field level, either surface methods or sprinklers can be used. Where land is too uneven to be economically levelled, a sprinkler system may be used.

e. Soils—Although most soils can be irrigated, there are some exceptions. Soils high in salts or sodium will not likely produce well enough to warrant the expense of irrigation. Fine-textured clay soils may not take water fast enough and may slowly become saline due to poor drainage. Coarse-textured, sandy soils may be so low in water-holding ability that extremely frequent irrigations are required.

Note: Both soil and water samples may be submitted for analysis to: The Saskatchewan Soil Testing Laboratory, University of Saskatchewan, Saskatoon.

REFERENCES

Irrigation in Saskatchewan. Canada Department of Agriculture and Saskatchewan Department of Agriculture.

Irrigation Water, Its Use and Application. Canada Department of Agriculture.

Water Development Under the Prairie Farm Rehabilitation Program. Canada Department of Regional Economic Expansion.

IRRIGATION METHODS

Selecting a method of irrigation depends on the crop to be grown, soil type, topography, land slope, and the amount of water available. Water can be applied by natural spreading over the surface or from sprinklers.

Most irrigation methods require levelling the land, constructing ditches to supply water and drain off surplus water, and installing structures for water control.

Land levelling is essential for surface irrigation and often desirable for sprinkler operations. It requires detailed surveys and plans to be effective. Seed annual rather than perennial crops after heavy levelling, as some soil settlement and swelling may require further planing, particularly for a border dyke system.

Surface Irrigation

1. **Spring Flood**—Spring runoff water is diverted, either by gravity or pumping, into fairly level areas where it is retained and spread by dykes. Each flooded area is provided with an outlet structure for draining. The water should be held only until it has soaked down about 3 feet and then the excess drained away. A week or 10 days is usually enough. This method is suitable for most soils but is usually used on lands producing hay. Since this is a low-cost method of applying additional moisture, even a moderate increase in yield may justify a development of this kind.

2. **Border Dyke**—Parallel dykes approximately 6 inches high are constructed 20 to 50 feet apart running in the direction of the land slope. Water from the head ditch is turned into each strip at the top end and flows down the length of the strip between the dykes. The strip must be levelled between the dykes and the downfield slope must be uniform, with not less than 1 foot fall per 500 feet and not more than 1 foot per 50 feet of length.

The border dyke method is suited for all close-growing crops, such as hay and grain. The method requires a relatively low labor input and is one of the faster and more efficient ways of irrigating. Farm machinery can cross over low border dykes.

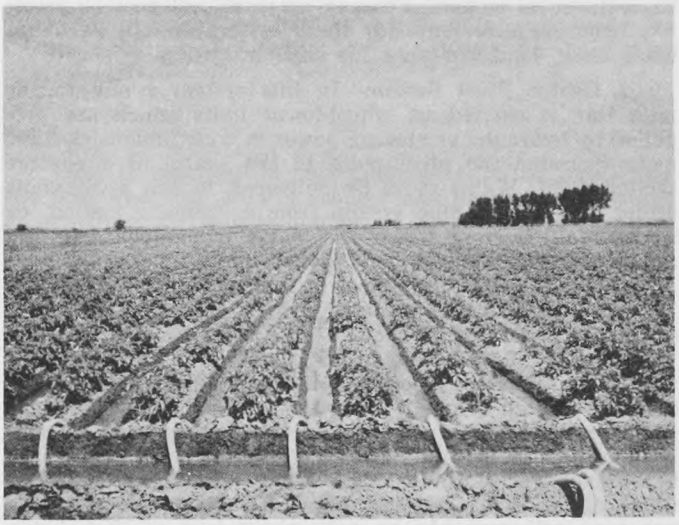
The capital investment to develop a border dyke system will range from $60 to $110 per acre, depending on the amount of land levelling required. Labor for irrigating will require about 2 hours per acre for each irrigation.

3. **Border Ditch**—Parallel ditches 75 to 125 feet apart are run down the field in the direction of the land slope. Each strip is irrigated by diverting water from the ditches to one or both sides at intervals down its length. The field ditches serve as drains after irrigation is completed. This method may be used on imperfectly levelled land from which excess water would not drain properly. It should only be considered as a temporary system until levelling can be done to permit using a border dyke system. Farm machinery cannot cross over the border ditches.

4. **Furrow and Corrugation**—Furrow or corrugation irrigation uses small channels running downfield at a spacing of from 2 to 4 feet. In row crops, the channel is the furrow between the rows, usually about 3 feet apart. The narrower spacing is used on solid-seeded crops in conjunction with a border dyke system. The channels or furrows serve as directional guides and enable uniform water distribution on steeper and more variable slopes than is permissible on most border dyke systems. To irrigate row crops, the water is distributed to each furrow by means of syphons, small turnouts, or gated pipe.

Water for corrugations may be delivered to the centre of a strip by turnouts or syphons, from where it spreads across the top of the strip to each corrugation, or the water may be carried in gated pipe and delivered at intervals across the strip. Gated pipe replaces the field supply ditch and can be used with gravity flow or under pressure supplied by a pump. Flow from the pipe is regulated by a series of small gates along its length.

Initial costs for developing furrow irrigation will vary from $50 to $100 per acre, and labor for irrigating may be slightly more than for a border dyke system, about 2 hours per acre for each irrigation.



Furrow irrigation system

Sprinkler Irrigation

Water under pressure is conveyed through a network of portable aluminum pipe and distributed above the crop through rotating sprinklers. Pressure may be from gravity but is usually developed by a pump operated by an engine or electric motor.

Sprinkler irrigation can be used on many crops and is particularly applicable on land where surface irrigation is difficult or impossible. Water can be applied to land which has had little or no levelling, ditching, or dyking. It permits a degree of control of water application, which is advantageous on coarse-textured soils and when frequent light

applications are required. Two disadvantages are the high capital and operating costs and the uneven distribution of water when sprinklers are used during windy periods. Sprinkler nozzles may be varied to provide the required quantity of water for a range of operating pressures.

Drainage of excess water is equally necessary with sprinklers as any other method. Careful application of water should minimize this but when used on undulating land there may be accumulation of water in low spots which must be drained. Land levelling along with the use of sprinklers may often be done for this reason.

Areas on which large sprinkler systems are to be used must be free of obstructions such as cross fences, buildings, or internal shelterbelts.

1. **Wheel-Roll System**—This system consists of a sprinkler line of 4- or 5-inch aluminum pipe, usually one-quarter mile long, supported on 5- or 7-foot diameter wheels which can be propelled by an air-cooled engine in the centre of the line. The pipe serves as an axle and is rigidly fixed to the wheels. When the power unit is engaged, the wheels roll a predetermined number of revolutions to move the sprinkler line to the next set. Labor is required to connect and disconnect the moveable line and the main line, and to operate the power unit on the sprinkler line when the set is changed.

The distance of the pipe from the ground is equal to the radius of the wheels, hence it is satisfactory only for low-growing crops. The soil should have an infiltration rate of at least one-half inch per hour so that the maximum length of set is not more than 8 hours to apply 4 inches of water.

The cost of a wheel-roll system will vary with the number and length of laterals, the pump, power, and pipe facilities required to supply water to the system. One lateral can accommodate up to 80 acres but the lowest cost per acre system would be a two-lateral system, each one-quarter mile (1,320 feet) long, to irrigate about 160 acres. Initial cost would be about $16,000 ($100 per acre for 160 acres). On soils with a low infiltration rate a four-lateral system would be required at an initial cost of up to $24,000 for 160 acres.

Labor requirements for these systems would be about one-quarter hour per acre for each irrigation.

2. **Centre Pivot System**—In this system a one-quarter mile line is carried on wheel-tower units which are propelled by hydraulic or electric power in a continuous circular motion around the pivot point in the centre of a quarter section field. Water must be delivered to the pivot point either in a closed pipe system from a pumping station, or by open ditch from which the water is pumped into the sprinkler line at the required pressure.

Without special equipment to irrigate the corners, about 133 acres of a square quarter section are covered by the system. One unit with adequate pumping capacity can serve 2 quarter sections, or about 265 acres, but will require a water supply to each pivot point and two moves of the system for each complete irrigation.

The height of the sprinkler heads above the ground enables its use in high- as well as low-growing crops and, because of the continuous movement, offers more uniform water distribution than the wheel-roll. Labor requirements per acre will probably be only about half of that for a wheel-roll system.

The prices of units will vary according to their design. The total installed cost will depend on the size and capacity of the pump, type of power used, and whether water is conveyed to the unit by pipe or open ditch. Units designed to irrigate up to 133 acres may be installed for about $22,000. Higher capacity systems with electric pumps and pipe lines to serve two settings may cost about $30,000. The capital cost per acre for a unit used on two settings is obviously much less than if it is used on only one field. There may be periods when the capacity of the system is not adequate to meet the desirable water demand on both fields, but the production loss may not be enough to warrant a higher investment in the irrigation equipment.

3. **Hand-Move System**—The first portable light-weight sprinkler irrigation systems were moved by hand. These systems are versatile in that they can be designed to fit any size and shape of field. The initial cost for hand-move systems varies from $75 to $100 per acre, and the labor requirement for each irrigation will be about 3 hours per acre. When larger, uniformly shaped fields are to be irrigated, the mechanical-move systems requiring less labor are generally more suitable.

Cost Comparison

Comparing capital costs of surface and sprinkler irrigation systems is difficult, because land levelling requirements, water supply, and drainage works vary from field to field. Some of the mechanical-move systems are limited to large acreages. An estimated average cost per acre, based on limited data available, indicates that capital costs for sprinkler systems are from 10 percent to 20 percent higher than for surface irrigation. Annual costs are correspondingly higher for sprinkler systems.

REFERENCES

Economics of Land Levelling in Alberta. Alberta Department of Agriculture.

The Engineering Aspects of Land Levelling. Canada Department of Agriculture.

MANAGING AN IRRIGATED FARM

Irrigation farming involves a number of special management considerations peculiar to this type of agriculture.

Higher per-acre capital investment and operating costs will be experienced as compared to dry land operation.

For growing the lower return crops such as forage and cereals, a gross yield equivalent of $50 to $75 per acre will usually be required to meet all fixed and operating costs and give a reasonable return to labor. Spring flood irrigation is an exception; a very small increase in returns will cover the cost of many spring flood projects.

For specialty crops both costs and returns will be higher—running as high as several hundred dollars per acre.

A more complex balance exists between soil, fertility, water, and plants when optimum quantities of water are made available to the soil. Special attention must be given to soil management to maximize yields, but at the same time preserve the tilth and make the best use of fertilizers and soil-building elements. Water-use characteristics of various crops must be observed and studied to insure that water is being applied at the proper time and in proper quantities.

The establishment of suitable crop rotations which will maintain soil fertility and provide a stable income is important. Careful study must also be given to the combining of field crop production with other enterprises, such as feeding livestock, after due consideration of market opportunities.

WATER APPLICATION AND IRRIGATION PRACTICES

The rate at which water is delivered to fields for irrigating is usually expressed in cubic feet per second (cfs). Most pumping equipment is rated in U.S. gallons per minute.

One cubic foot per second = 6.23 igps = 374 igpm
= 7.5 U.S. gps = 450 U.S. gpm
= one acre inch per hour (approx.)
= one acre foot per 12 hours

igps (m) = imperial gallons per second (minute)

U.S. gps (m) = U.S. gallons per second (minute)

One acre foot=1 foot of water over 1 acre=43,560 cubic feet
=271,379 imperial gallons=325,850 U.S. gallons
One acre inch=1 inch of water over 1 acre=3,630 cubic feet
=22,615 imperial gallons=27,154 U.S. gallons

The capacity of an average dugout is less than 3 acre feet. This quantity is obviously not enough to irrigate more than a garden area in addition to domestic and livestock requirements on a farm.

The irrigation requirement for a crop is the difference between the total water requirement and the rainfall. Average rainfall is about 8 inches during the growing season. The annual water requirements of most crops grown in Southern Saskatchewan will range from about 19 inches for cereals to 24 and 26 inches respectively for grasses and alfalfa. Potatoes need 21 inches and flax about 15 inches for highest yield and quality.

There are wide variations in irrigation requirements from year to year. High precipitation and low evaporation rates will reduce the need for irrigation, while limited rainfall and hot, windy weather will increase it. Northern areas, because of lower evaporation, may require less water for irrigation. Information on crop requirements and average rainfall for each area may be obtained from the Extension Division, University of Saskatchewan, and CDA research stations.

Most field crops obtain about two-thirds of their total water requirements from the top 2 feet of soil. The effective root zone is about 2 feet for shallow-rooted vegetable crops, 3 feet for most grasses, cereals, and root crops, and as much as 5 or 6 feet for taproots of alfalfa. To provide a constant supply of water for the growing crop, the best time to irrigate is when the available supply within this active root zone has been reduced by one-half. An exception to this general rule occurs with potatoes, which require irrigation when one-quarter of the available water supply has been used.

The only reliable way to determine the moisture supply is to sample the soil frequently. Samples should be taken from several field locations to the depth of the root zone of the growing crop. These samples are formed into a ball by firmly squeezing a handful with the fingers. When a relatively firm ball is formed, and if, on squeezing, moisture is left on the hand, then the soil contains most of the water it can store, and irrigation may be deferred. When the ball crumbles or will not hold its shape (clay soils will form a weak ball) the soil has already become too dry, with the result that yields will be reduced, and the crop should be irrigated without delay to prevent a further reduction in yield. Very sandy soils do not readily form a ball but tend to stick together slightly when three-quarters or more of the available water is present in the soil.

The amount of available water which soils will hold differs according to the texture and uniformity of the soil profile. These characteristics also influence the rate at which water will flow into the soil surface during a rain or an irrigation. Sandy soils take water very readily but hold only from three-quarters of an inch to an inch of available water per foot of depth. Clay and silty-clay soils absorb water very slowly but the greater number of smaller pore spaces will hold from 2 to 2½ inches of available water per foot of soil.

Several checks with an auger, shovel, or soil probe should be made in each field to a depth of 4 to 6 feet 2 days after an irrigation. If the soil moisture is evenly distributed to the depth of the root zone, the irrigation has been good; if dry areas are found in this region, not enough water was applied; if the soil is too wet below the root zone, too much water was applied. Corrections can then be made at the next irrigation.

For larger scale projects, the need for irrigation can be predicted by means of a water budget system based on weekly evaporation, crop factors, and precipitation records. This method is most practical when the technical know-how is provided by irrigation specialists working on the project. When specific information is not readily available, the following general guidelines, based on research and experience, will help to give the desired results.

Alfalfa and Alfalfa-Grass Mixtures

Alfalfa and alfalfa-grass mixtures should be irrigated in the spring when the stands are 6 to 8 inches high. Dry soil conditions will require earlier irrigation before this stage of growth. Irrigate again immediately after the first cutting. After the second cutting a further irrigation may depend on availability of irrigation water and the general soil moisture conditions. Fall irrigation of forage crops is not as beneficial as early spring irrigation.

Alfalfa grown for seed should not be irrigated during the blossom stage.

Grasses grown for seed need an early spring irrigation and one after harvesting the seed. Any additional irrigation will depend on local moisture conditions.

Grain

A light irrigation when growth reaches 4 to 6 inches is usually beneficial. The main irrigation should be at the shot-blade stage; another may be required when the heads are filling, depending on soil moisture conditions.

Potatoes

Plant potatoes in moist soil. The first irrigation should be light and applied when the potatoes are just beginning to set. The second irrigation should wet the root zone to 2 feet and the wetting pattern should connect laterally 3 or 4 inches below the ground surface under the row. Make frequent light irrigations every 2 weeks until late August. No water should be applied for about a month before harvest, as the tubers must have time to mature properly. A light application after defoliation may be desirable to provide better soil conditions for harvesting operations.

Corn

Corn is sensitive to too much water. Two irrigations, the first when the crop is about 2 feet high and the second at tasselling, are usually enough.

Rapeseed

Irrigate after emergence, at blossom stage, and prior to maturity.

Horticultural Crops

These crops require a soil moisture level of above 50 percent. Generally, light and frequent irrigations are recommended.

REFERENCES

Forage Crops for Irrigated Land in Southern Alberta. Canada Department of Agriculture.

Growing Irrigated Crops in Southern Alberta. Canada Department of Agriculture.

Growing Irrigated Crops on Canadian Prairies. Canada Department of Agriculture.

Irrigation in Central Saskatchewan (P.F.R.A. Demonstration Farm). Canada Department of Regional Economic Expansion.

Seasonal Consumptive Use of Water by Crops Grown in Alberta and Its Relationship to Evaporation. Canada Journal of Soil Science, L. G. Sonmor.

DRAINAGE

An adequate drainage system is required for surface irrigation and may also be required where sprinklers are used on undulating land with depressions which do not drain freely. Accumulation of more water than the soil can hold will result in crop damage, and probably soil damage.

Soil Salinity

Where conditions prevail which do not permit surface or ground water to drain away satisfactorily, an accumulation of soluble salts will occur at or near the surface of the soil due to water evaporation. This increased concentration of salts will adversely alter the soil structure, permeability, and aeration characteristics. Under these conditions plant growth is retarded due to decreased water uptake or by direct chemical or toxic effect.

Since recovery of salinized soils is expensive, difficult, and often virtually impossible, great care and caution should be taken to prevent such an occurrence.

In planning an irrigation project, the soil profile should be carefully investigated to determine its capability of transmitting surplus water to natural or artificial drains. Tight clay subsoils can be expected to restrict the ready movement of excess ground water and, therefore, should not be irrigated unless an elaborate system of drains is provided. Soils already high in soluble salts should also be avoided.

Salinity problems under irrigation can be minimized by: a. The provision of a network of drains which will remove all surplus surface water; b. lining canals, laterals, and head ditches, where necessary to prevent seepage; c. proper land levelling and field layouts to prevent ponding and provide uniform water distribution; d. acquiring a knowledge of crop water requirements and soil water-holding capacity; e. practising good water management; f. avoiding irrigation of summerfallow or uncropped land.

Land Reclamation by Drainage

During recent years there has been an upswing in the draining of sloughs and potholes to assist modern farming methods and to enable cultivation of additional lands. Unfortunately, the water which is drained must move on to a new location and in doing so it sometimes causes damage or inconvenience to others along the way. This damage could consist of erosion, pollution, flooding, or even a delay in being able to work the land. A person who constructs or operates drainage works is considered to be responsible for the water which is drained up to the point where it reaches a "sufficient outlet." A "sufficient outlet" is that point where the water may be discharged without doing any injury to lands, roads, structures, or other property. Generally a road ditch cannot be considered to be a sufficient outlet.

The Saskatchewan Department of Agriculture administers the Private Ditches Act, the Drainage Act, and The Conservation and Development Act, which provide for authorized drainage of agricultural lands. Persons responsible for the construction and operation of authorized or unauthorized drainage works could be liable to a civil action for damages which may be caused by the drained water.

REFERENCES

Slough Drainage and Cropping. Canada Department of Agriculture.
Soil Salinity and Drainage Problems. Canada Department of Agriculture.

AGENCIES INVOLVED WITH IRRIGATION

Local Agricultural Extension Offices.
Saskatchewan Department of Agriculture, Conservation and Development Branch, Government Administration Building, Regina.
Canada Agriculture Research Station, Swift Current.
Canada Agriculture Research Station, University Campus, Saskatoon.
Agricultural Engineering Department, University of Saskatchewan, Saskatoon.
P.F.R.A.: Motherwell Building, Regina;
Demonstration Farm, Outlook;
and local offices.
Saskatchewan Water Resources Commission, S.P.C. Building, Regina.
South Saskatchewan River Project, Outlook, Saskatchewan.

FARM BUSINESS MANAGEMENT

THE ROLE OF THE FARM MANAGER

A farmer's most critical job is managing his business. Management is even more important than how hard a farmer works—mainly because the modern farm business is large, requires a heavy investment, and is a complicated operation. As a result, the effect of good or poor management shows up quickly and has a strong influence on farm earnings.

The key role of the manager is making decisions needed for running the business. This includes all decisions which have something to do with how the farm is organized and operated—e.g., decisions about buying a farm, borrowing money, what machinery to buy, whether or not to go into livestock, what to seed, etc. Some decisions are very important and may affect the family's livelihood for many years to come. Other decisions are less critical. All decisions, however, have some bearing on how successfully the farm operates. Over time, the farmer who makes more of the right decisions gets ahead faster and enjoys a more satisfactory level of living.

The first step for making good management decisions is to decide on goals and objectives. Management decisions are easier to make if a farmer and his family know what their personal goals are and what objectives and expectations they have for the farm business. By relating decision-making problems to goals and objectives, the purpose of the decision can be kept in mind.

Goals and objectives require careful thought and understanding—particularly as to the relationship between goals for the family and goals for the business. It is also important to be realistic about the economic conditions under which the farm must operate and the income that can be expected. Conflicts may appear to exist between the needs of the farm and the needs of the family—especially during the developing stage of the farm business. During this period the farm usually needs to expand as quickly as possible in order to increase farm earnings. However, the family may need extra income at the same time. This situation forces a choice between using farm earnings to develop the farm business or using this income for personal purposes. Where such conflicts exist they must be reconciled before the right decision can be made.

The task of making correct management decisions is difficult because it forces the manager to predict the future. A farm manager often does not have all of the information needed for analyzing problems and alternatives. He may be uncertain about production performance or requirements, policy developments, markets, prices, costs, etc. Although these problems exist, a good manager concentrates on those things over which he has some control. This includes obtaining the most up-to-date information available, seeking advice, and adopting a systematic logical approach to analyzing problems and making decisions. While this approach does not guarantee that all decisions made will turn out to be the best decisions, a higher percentage of sound decisions can be expected.

FARM BUSINESS PLANNING

The basic purpose of planning is to have a better idea of what to expect of the farm business in the future. It involves projections as to the probable outcome of alternative courses of action (e.g., beginning farming, adding or expanding an enterprise, buying machinery, etc.). It is also useful for testing the effect of changes in prices, costs, market conditions, etc. The planning process must be a continuous one, calling for revisions as new information becomes available or as circumstances change.

Some alternatives are fairly simple to evaluate, and require little planning. Others are more complicated and usually require considerable calculation. For such alternatives the planning task may involve estimates of resource requirements, costs, prices, production, returns, and cash flow.

Tools of Farm Planning

A farm manager can use various "tools" or techniques to assist him in planning and managing his farm business. Some of these tools are explained below.

Farm Records

The basic purpose of farm records is to provide information about the farm business which will help a farm manager to understand the business. A good set of records provides cost-and-returns analysis summaries which reveal whether or not the business is basically sound. It also provides information required for farm planning, income tax filing, net worth calculations, obtaining credit, business arrangements, estate planning, and other purposes. However, to obtain the full value of records, it is necessary to have reasonably complete and accurate records, and to study the information which they provide.

In selecting a record-keeping system it is important to have a system or method which satisfies the needs of the business. The types of information that should be provided include: Farm inventories (land, buildings, machinery, livestock, grain, and supplies); credit transactions (records of individual loans or accounts receivable); expenses and receipts (operating expenses and income; capital purchases and sales); labor records (including deductions and contributions for Canada Pension Plan (C.P.P.), unemployment insurance, and income tax); information for income tax filing; year-end summary and analysis (total business and individual enterprise performance); production records (yields, feed fed, rate of gain); net worth statement; personal records.

Many farmers still use the "scribbler" or "shoe box" methods of keeping records. It should be realized that while it is possible to file income tax returns from such records, they are not adequate for providing much of the information indicated above—particularly business analysis information.

The following two systems of record keeping are recommended to Saskatchewan farmers. Both systems are capable of providing all of the information requirements listed above.

1. **Prairie Farm Account Book**—This account book permits flexibility in farm accounting. It can be used for income tax filing, farm business analysis, and other purposes. The account book has provisions for both total farm analysis and analysis of individual enterprises. The Saskatchewan Department of Agriculture provides a reference manual "Farm Accounting Instruction Manual" and a low-cost farm analysis service.

2. **Can-Farm (Canadian Farm Management Data System)**—This is a mail-in record-keeping system developed on a national basis for use throughout Canada. It is intended to satisfy the record-keeping needs of individual farmers and also to provide data for research requirements. Farmers

who are on the system complete monthly journals of their records and have them mailed to a central office. An electronic computer records the information and prepares printed statements and summary reports which are returned to the farmer monthly. Additional information on Can-Farm is available from the Saskatchewan Department of Agriculture and the Department of Agricultural Economics, University of Saskatchewan, Saskatoon.

Methods of Making Projections

Calculation or estimating techniques are useful for making financial projections about the farm business. The approach to use depends on whether the whole or only part of the farm business is affected.

Total Farm Projections—Projections for the total farm take into account all costs and income. Calculations can be made to show expected returns from a particular farm or to compare returns from different kinds of organizations. This type of calculation is done for projecting returns where a major reorganization is involved, to work out a plan for obtaining credit or determining a repayment schedule, for estimating returns before one begins farming, or to show the present returns' picture where adequate records are not available. Although calculations of this nature are usually done for the farm as a whole, they can also be done for a particular enterprise.

Projections for Individual Changes—In examining the effects of a change that involves only part of the farm business, **only those costs and returns that are actually affected need to be considered.** This simplifies the types of calculations required for making financial projections, as it is unnecessary to know the present cost and returns' structure of the farm. Examples of the types of changes that might be examined with this approach are: Adding, expanding, or discontinuing an enterprise; purchasing a machine; changing a management practice (e.g., fertilizer use).

The following outline can be used to systematically estimate the net effect of an individual change. Although some of the headings may not apply for certain types of changes, they are included to serve as a reminder to take into account all of the items which might affect returns resulting from a particular change.

Proposed Change		
Items That Reduce Returns:		
Added Costs		
Fixed Costs	$.....	
Variable Costs	$.....	
Reduced Income	$.....	
Total		$.....(A)
Items That Increase Returns:		
Added Income	$.....	
Reduced Costs	$.....	
Total		$.....(B)
Net Change (B-A)		$.....

The terms used in the outline above can be explained as follows:

Items That Reduce Returns

Added Costs include only those costs that would be **added** if the change is made. Fixed costs exist whether an item is used or not—e.g., depreciation and investment cost for machinery and buildings. Fixed costs are shown only if they are incurred because of the change. Variable costs vary directly with the amount of use—e.g., repairs, fuel, seed, and hired labor.

Reduced Income allows for income no longer received if the change is made—e.g., feed grown on the farm and fed rather than sold, income from an enterprise replaced, off-farm wages or custom work, lower yields resulting from loss in timeliness, foregone interest on capital used.

Items That Increase Returns

Added Income includes all expected additional income from sales or services provided—e.g., grain sales, livestock sales, custom work done.

Reduced Costs allow for annual costs no longer incurred if the change is made—e.g., reduced cropping or livestock costs, reduced labor costs, reduced transportation costs.

The above steps allow for all changes in income and costs, but do not include the operator's labor and management. The purpose of this procedure is to estimate the net change to the operator's labor return—i.e., whether it increases or decreases, and by how much. The following example illustrates the above technique.

Example: Estimating Net Change to Operator's Labor Return

Proposed Change: to purchase an additional quarter section of land for $12,000 (150 acres cultivated, half seeded, existing line of machinery and labor used, extra grain storage required).

Items That Reduce Returns			
Added Costs			
Fixed Costs ($480: extra grain storage bin):			
Depreciation $480 / 30 years	= $ 16		
Investment Cost (average) $480 x 7½% / 2	= 18		
Taxes	= 170		
Interest on Land $12,000 x 7½%	= 900		
Total			$1,104
Variable Costs			
Seed and Sprays	$ 300		
Fertilizer	150		
Machinery—Fuel and Repairs	360		
Grain Storage Upkeep	10		
Total			820
Total Added Costs			$1,924
Reduced Income			
Custom Spraying			100
Total			$2,024 (A)
Items That Increase Returns			
Added Income			
75 Acres Wheat at 24 bu/ac = 1,800 bu at $1.35		$2,430	
Reduced Costs			
Custom Spraying Operating Costs		30	
Total			$2,460 (B)
Net Change (B-A) = $2,460 − 2,024			$ 436

The above example does not include principal payments for land. Principal payments for land are a form of savings and would have to come out of the $436 net change. The $436 net change indicates the expected increase in operator's labor return.

Cash Flow Projections—A cash flow projection is a statement which lists the timing and the amount of cash coming in and going out of the business during the year. It is a necessary supplement to farm projections which are based on what the farm produced during the year rather than what was sold. A cash flow projection shows whether or not money will be available when needed. This cash may be for operating the farm, making loan payments, and for living requirements. The projection is essential even though other calculations may show the farm is expected to be profitable. Cash flow problems are more necessary for certain types of business ventures than for others—mainly those types of ventures where loan repayments do not occur in the same period as that in which income will arrive (e.g., cow-calf operations). Other situations which may lead to cash flow problems are where forced savings are involved (e.g., paying for land) and where marketing problems exist (e.g., slow grain sales). A cash flow projection is also useful for determining how much credit may be required and when it is needed.

Farm Planning Guides—1. Prices, costs, and other information used should be related to the individual farm situation.

2. To allow for risk and uncertainty, use a range of prices, yields, and other data which may vary. An insurance cost can also be included.

3. Use current prices adjusted with the best available outlook information for decisions having short-run implications. Use average prices for longer run decisions and make allowances for price trends over time.

4. Charges for grain and roughage fed to livestock should be based on market prices at the farm—not on what it cost to produce the feed.

5. Depreciation allowances should be high enough to fully cover the cost of buildings and equipment during the period of use. Allow for possible obsolescence.

6. Cash flow projections should be made for the transitional period as well as calculations showing the average situation when full production is achieved.

7. When borrowed money is required, repayment terms should be related to annual income.

8. Although calculations may show a particular change would be profitable, other alternatives should also be investigated before a final decision is made.

9. Farm planning should take into account shifts in labor and management requirements, conflicts in equipment and labor use, feed supply and requirements, suitability of debt repayment terms, cash flow, and other factors relating to the successful operation of a farm business.

10. Budgeting and planning reference—**Planning For Profit** available from the Saskatchewan Department of Agriculture.

11. Individual assistance—contact farm management specialists with the Saskatchewan Department of Agriculture and the Department of Agricultural Economics, University of Saskatchewan, Saskatoon.

COST OF OWNING AND OPERATING MACHINERY

Management decisions with respect to the selection and use of farm machinery can greatly affect the financial success of a farm. Machinery-cost management involves making decisions regarding: Machine size and type, custom hiring, purchase of new or used equipment, machine replacement, and the level of investment in machinery that can be justified. The basis for sound machinery-management decisions is an accurate evaluation of the costs of owning and operating machinery.

Annual Costs

Some costs occur regardless of the amount of use of a machine and are calculated on an annual basis. Such costs include depreciation investment cost, and insurance and housing.

Depreciation refers to the loss in value of a machine which occurs due to wear and obsolescence.

Investment cost represents the cost of borrowing money or of the interest which could be earned if the capital were invested elsewhere. It is determined by taking a percentage of the average annual investment.

Insurance and housing costs allow for the risk of equipment loss, housing, and for a possible higher depreciation and repair cost which may result if equipment is not housed. Usually 1 percent of the original cost of the machine is used to cover the annual cost of insurance and housing.

Hourly Costs

Some costs occur only when a machine is used. These costs include fuel, lubrication, repairs, and labor. Since these costs vary with the amount of use, they are expressed on an hourly basis.

Fuel costs can be estimated on an hourly basis. Lubrication costs vary between machines, but generally a 10-cent-per-hour charge will cover the cost of grease, oil, and filters.

Repair costs per hour can be determined by estimating the total repair cost for the life of the machine and then dividing by the expected normal lifetime hours of use. The lifetime repair cost allowance could be based on a percentage of initial investment.

Labor may be charged as either the cost of hired labor or the estimated value of the owner's labor.

Application of Machinery-Cost Calculations

Using the budgeting outline and guides for repair rates, hours of use, and years of life shown in the following table, the costing procedures outlined in the preceding section can be used to determine total costs of equipment on an annual, hourly, or acreage basis. It is emphasized that the figures shown below may require adjustment to fit individual situations.

Machinery-Cost Calculation Guides

	Depreciation Lifetime*	Typical Annual Use**	Total Lifetime Use †	Repair Rate (% of Original Cash Cost) ††	
	Years	Hours	Hours	Average	Range
Tractors	13	600	7,800	40	30–50
Combine, Baler, Forage Harvester	12	150	1,800	50	40–65
Swather, Mower, Rake	15	100	1,500	35	25–45
Tillage Equipment	15	160	2,400	30	20–90
Seeding Equipment	15	100	1,500	30	20–40
Sprayers, Loaders, Harrows, etc.	15	40	600	30	20–40

* — Number of years required for the machine to depreciate to 10% of its original purchase price.
** — Estimated on the basis of average farm requirements.
† — Estimated by multiplying lifetime in years by normal annual use in hours.
†† — Estimated repair rate is based on the lifetime normal use in hours. These two figures are tied together, since the repair rate must always relate to a specified amount of use. The repair rate also includes a margin for the value of time required for doing repair work. The above repair rates are guides only and may require adjustments to fit individual situations.

Example: Calculation of Machinery Costs

Machine—Combine Original Cash Cost—$14,000
Years Use **12.** Annual Hours Use **150.** Lifetime Hours Use **1,800.** Repair Rate (%) **40.**

Annual Costs:

1. Depreciation

$$\frac{\text{Original Cash Cost} + \text{Cash Sale Value}}{\text{Years of Use}} = \frac{\$14{,}000 - \$1{,}400}{12} = \frac{\$12{,}600}{12} \quad \$1{,}050$$

2. Investment Cost

$$\frac{\text{Original Cash Cost} + \text{Cash Sale Value}}{2} \times \text{Interest Rate} = \frac{\$15{,}400}{2} \times \$.07 \quad 540$$

3. Insurance and Housing

Original Cash Cost x 1% 140

Total Ownership Costs per Year $1,730

Hourly Costs:

4. Fuel, Oil, and Grease
Gal/Hr x Price/Gal 1.08
Plus Oil and Grease per Hour .10

5. Repair Allowance

$$\frac{\text{Original Cash Cost} \times \text{Repair Rate}}{\text{Lifetime Use (Hours)}} = \frac{\$14{,}000 \times 50}{1{,}800} \quad 3.90$$

6. Labor (Where Applicable) 3.00

Total Operating Costs per Hour $ 8.08

Summary of Total Costs

1. Per Year = Annual Cost + (Cost/hr x Annual Hours)
$1,730 + ($8.08 x 150) = $1,730 + $1,212 = $2,942
2. Per Hour = $\frac{\text{Total Cost/Year}}{\text{Annual Hours Use}} = \frac{\$2{,}942}{150} = \$19.61$

Cost Per Acre—To determine the maximum number of acres that can be covered in an hour by various field operations, the width of the machine in feet is multiplied by the speed of travel. Factors such as overlap, turning, making adjustments, loading grain and fertilizer, and unloading grain from combines reduce the efficiency of various operations to less than maximum. Generally field efficiency of tillage operations will be about 80 percent while seeding and harvesting operations will be 70 percent or less.

The following formulae can be used to calculate approximate acres per hour for tillage and harvesting operation.

Tillage operation

$$\text{acres per hour} = \frac{\text{width of machine (ft)} \times \text{speed mph}}{10}$$

Harvesting and seeding

$$\text{acres per hour} = \frac{\text{width of machine (ft)} \times \text{speed (mph)}}{12}$$

Custom Rates

One alternative to owning machinery is custom hiring. Although custom rates often are based on traditional or common rates in an area, such rates may not be realistic when related to the actual cost of doing the work. Custom rates normally should cover annual and hourly costs of a machine and also provide a profit margin.

Margins for Custom Work—Hourly costs of different custom operations will vary depending on weather conditions, soil type, presence of stones or roots, and travel time. To cover the added cost resulting from these factors, operating costs calculated for normal conditions are increased. The adjustment will usually range between 20 and 40 percent depending on the type of operation and operating conditions.

Custom Rate Calculation—To determine the cost per hour for custom work for the combine example, the hourly costs of $8.08 should be adjusted to compensate for abnormal **operating** conditions, etc. If we assume a 40-percent adjustment then the custom rate per hour would be:

Adjustment = $8.08 x 40 = $3.20

Total cost per hour = Total cost per hour + cost adjustment for custom work = $19.61 + $3.20 = $22.81

Examples of Custom Rates

The following rates were calculated on the basis of the foregoing procedures and guides. All costs, including labor, are taken into account. Labor was valued at $3 per hour for combining, and $2 per hour for all other operations. Investment cost was charged at 7% of average investment.
These rates are suggested as guides only, and may require adjustment for individual circumstances.

Operation	Machine Description	Original Cash Value	Repair Rate (%)	Acres Per Hour	Cost Per Acre				Cost Per Acre
					Annual Costs	Hourly Costs	Margin	Total Cost	
Tractor Only	Diesel	$11,000	40	—	$2.10	$1.65	$0.40	$4.15	$ —
Tractor and Labor	Diesel	11,000	40	—	2.10	3.65	0.90	6.65	—
Tractor and Labor	Diesel	6,000	40	—	1.20	3.15	0.80	5.15	—
Cultivating	14 ft Heavy Duty	1,400	70	7	2.15	3.55	1.05	6.75	0.95
	24 ft Heavy Duty	2,400	70	11	3.75	4.35	1.20	9.30	0.90
Discer	16 ft S.A. and F.A.	2,700	40	6.5	4.10	3.90	1.55	9.55	1.50
	(2 x 12) S.A. and F.A.	4,800	40	10	7.35	4.95	2.00	14.30	1.45
	(2 x 12) No Att.	2,600	35	11	4.90	4.25	1.50	10.65	1.00
Press Drill	24 ft	4,800	30	11	7.35	4.60	1.15	13.10	1.20
Rodweeding	36 ft	1,600	30	13	2.20	3.45	0.90	6.55	0.50
Harrowing	43 ft	800	30	20	3.20	3.55	0.90	7.65	0.40
Spraying	54 ft	800	40	20	3.20	3.70	1.10	8.00	0.40 + spray
Swathing	18 ft S.P.	3,400	35	8	3.50	3.40	1.10	8.00	1.00
	16 ft P.T.O.	1,400	30	7.5	2.75	3.45	1.05	7.25	0.95
Combine	S.P.	14,000	50	6–7	11.50	8.00	3.20	22.70	3.25–3.75
	P.T.O.	8,500	50	5.5–6	9.00	6.95	2.80	18.75	3.10
Baler	P.T.O.	2,200	60	125 bales per hour	2.85	3.90 without twine	1.50	8.25	6.5 cents per ball + cost of twine

Grain Trucking:
Field to Storage — 50c per acre.
Farm to Market — 3c per bushel for first 5 miles
+0.3c per bushel for each additional mile (limited distance).

FARM OPERATING ARRANGEMENTS

An operating arrangement is an agreement between two or more people to engage in a business venture which will use some part of the resources owned by each of the people involved. As the amount of land, labor, machinery, and livestock which is necessary to the success of a typical farm unit continues to increase, the use of operating arrangements will also increase.

Operating arrangements which enable the assets of a business to be owned by more than one individual are important when 1. there are efficiencies to be gained by operating a larger unit, and 2. individuals own relatively large amounts of one resource but are short of another and a person who is in the opposite position can be found.

In situations such as this it may be advantageous to both parties to operate in one of the following ways:

1. Set up a joint business venture in the form of a corporation, co-operative, partnership, or syndicate;
2. allow one of the parties to contract for the use of the other party's resources on a prepayment basis. For example, pay a cash rent for the use of a tractor or a parcel of land;
3. allow one of the parties to operate a business using the resources of both and have each receive payment for the use of his respective resources from a division of the production or income generated from the business. An example of this is a share-rental agreement for the use of land.

General Requirements

There are several factors which must be considered in all types of operating arrangements. Probably of greatest importance is the need for all parties to be able to get along together. There must be the desire and ability to conduct the operation in a harmonious manner. Before entering into an operating arrangement each party must feel that there are no personal conflicts or conflicts of interest that may lead to disputes and disagreements at a later date. Persons who have difficulty getting along beforehand may well find their differences intensified in an operating arrangement.

The size of the business must be large enough to obtain the kind of income flow which the parties are going to expect from it. If the expected income generated by the business will not meet the needs of the parties involved (and their families), expansion might be required. If so, this should be known at the outset.

The interests, ambitions, and requirements of people change over time. A farmer may acquire the responsibility of a wife and family a few years after he begins farming. A more elderly farmer may wish to cut back on his workload. All people change over time. Economic and social conditions also change. All operating arrangements should be entered into recognizing this fact. Later conditions will require new arrangements or the modification of previous arrangements. Provisions to allow for this modification are a necessity.

Fairness

Most people who enter operating arrangements are concerned that their arrangement be fair to all parties involved. There is much less agreement on how to calculate a fair arrangement. Because the three main types of agreements, namely, joint ventures, cash rent, and share rent, vary in the way in which resources from each party are controlled and remunerated, they also vary in how they can be judged for fairness.

In a joint venture both parties contribute resources and in most cases share in the managerial and operational decisions which determine the success of the business. In some cases the resources contributed by each party are quite similar. For example, two brothers may pool their land, labor, and capital and operate a farm together. Here it is recommended that they use the principle that each party receives returns in the same proportion as he contributes resources to the business.

Example: Two-Man Operating Arrangement

Farm Assets Contributed	Operator A	Operator B
Land (List)	$110,000	$35,000
Buildings and Improvements (List)	7,000	2,000
Machinery and Equipment (List)	18,000	6,000
Livestock (List Breeding Stock)	5,000	8,000
Total Assets	$140,000	$51,000
Annual Cost Contributions		
Depreciation — Buildings and Improvements	$ 350	$ 100
— Machinery and Equipment	2,250	740
Investment Cost (6%)	8,400	3,060
Labor and Management	4,000	3,600
Total Contributions	$ 15,000	$ 7,500
Percentage Contributions	66 2/3%	33 1/3%

In this example, Operator A would be entitled to two-thirds of the income and would be responsible for two-thirds of the cash operating costs. Operator B's share of income and cash operating costs would be one-third.

In the case of a cash rent it is recommended that the test for fairness be made on the basis of opportunity cost. Opportunity cost is a term that is used to define the cost of using a resource in a particular way. The opportunity cost is the income which is foregone by not using that same resource in the next best use that is available.

For example, a landowner may wish to determine whether or not he is receiving a "fair" cash rent for a section of land he owns and is renting out for $7 per acre. He might judge the cost of renting this land out by calculating the return the land would bring him if he:

1. Rented it out on a share lease; 2. farmed it himself by hiring the work done; 3. selling the land and investing the money in some other real estate or in bonds or stocks.

Each of these uses would have some costs in either money or social terms associated with it and these costs would have to be deducted in order to make the answers comparable. The best return from among these alternative uses could be regarded as the income foregone by renting the land out on a cash-rent basis. A fair cash rent would be one that returned a realized net return at least as great as the best alternative use.

The renter might appraise the situation in a similar manner. He might calculate how much income he could generate by using his resources, e.g., labor, machinery, in an alternative use.

The rental arrangement would only be "fair" to him if it gave at least as great a return as he could get by using his resources in the next best use. It should be noted that unless each party can get at least as much in payment for his resources when they are used in the operating arrangement as he could from the next best use, the arrangement should not be entered into. If both receive more than opportunity cost, then the sharing of this "profit" can be done only through a bargaining process.

In those cases where the business is operated in the main by one of the parties but payment is based on the income stream generated by the business, the determination of fairness is more complex. However, this type of arrangement in the form of crop-share leases is one of the most common in use today. Because it is a common form of operating arrangment, a tradition in each area of the province has been built up that may offer a starting bargaining position. That is, in many areas the ⅓-⅔ crop share to landlord and renter respectively, with the landlord paying taxes and repairs to improvements, is common. It is recommended that the parties to the agreement evaluate their position in regard to opportunity costs (see above paragraph) under the share rent common in their district. If either feels that this typical arrangement does not give him a return comparable to his opportunity cost, he should bargain with the other party in an effort to improve his position.

A separate category of operating arrangements is that engaged in by father-and-son combinations. These often tend to be joint business ventures, but the starting equity positions of the parties involved are such that attempting to use the concept of payment relative to contribution is of little practical use. In many of these cases the object of the joint venture is not to be fair in the sense of just payment for resources used. It is rather an attempt to aid in the transfer of assets between generations. In this case the best procedure is to determine how fast the parties wish to transfer the assets between generations. Once this is decided any given sharing arrangement can be tested to see if it meets the needs of this objective. If it does not, it can be adjusted accordingly.

Types of Arrangements

Hired-Labor Arrangements—Farmers find that it is difficult to hire and keep qualified labor. Therefore, they may need to resort to higher wages or better working conditions. One form of income incentive which may be beneficial to both parties is some form of profit sharing. This may take the form of incentives or bonuses which will be paid to the worker provided that the amount or value of production surpasses some predetermined level. A worker might be given the incentive of receiving so much for every high-quality hog that is sold. In this manner he is encouraged to take an active interest both in the quality and quantity of output as well as in remaining employed on the farm.

Wages to a son are often the first step in working the son into the business. Wages should be paid in cash to provide the son with capital with which he may either buy into the business or start on his own.

Machinery-Sharing Arrangements—Many farmers share individual machines, lines of equipment, all machinery, or exchange labor for machinery use in order to reduce machinery costs and release labor and limited capital for other uses. Investment, depreciation, and operating costs should be split according to use (acres, hours, or tons). For example, if farmer A uses a sprayer on 400 acres and farmer B on 600 acres, farmer A should be responsible for 40 percent and farmer B 60 percent of all costs. If the original investment is shared by each party and each provides fuel and lubrication when the machines are used on his farm, then only the repair costs need to be split at year-end.

The exchange of labor for machinery is commonly used by beginning farmers. The son uses the father's machinery and in return provides labor on the father's farm. A cash settlement can be made at the end of the year if one party contributes more than the other. The following example illustrates a procedure that may be followed for machinery-labor exchanges.

Example:

Machine-Sharing Arrangement—A father and son have 700 and 300 cultivated acres, respectively. The father owns all the machinery and the annual costs of this are $4,000 per year. Each provides fuel and lubrication when the machines are used on his land. Repairs of $1,000 paid by the father are to be shared. The son's labor on the father's farm is estimated at $1,200.

In this case the father has contributed his own share of the machinery costs plus,

a. the son's share of annual machinery costs
   i.e., $4,000 x 30% = $1,200
b. the son's share of the repair bill
   i.e., $1,000 x 30% = 300
   Total = $1,500

The son has contributed labor worth $1,200. Therefore a payment by the son to the father of $300 will balance the transactions for the year.

Incorporation—Incorporation of a farm in Saskatchewan can be obtained by registration either under the Companies Act as a "Company" or under the Co-operative Production Association Act (1967) as a "Co-operative" or "Mutual." Both types are similar in many respects but may differ in regard to control and in the distribution of surplus or profit. A "Company" is controlled by the person or

groups who hold more than 50 percent of the voting shares, while in a "Co-operative" members have equal voting power and the majority rules.

A company may have several types of share structure (common, preferred, voting, non-voting, participating, cumulative, redeemable). For this reason it may be better suited to estate planning. A co-operative has the advantage of being less expensive to incorporate. It is well suited to situations where each party contributes about the same amount of capital and all shareholders provide labor and management.

Advantages common to both types include: Possible income tax savings; estate planning and transfers; credit availability; limited liability; and perpetual existence. Record-keeping requirements and annual financial audits are required in more detail than for other types of business forms. This, however, may improve management.

Disadvantages include the cost of transportation and the annual auditing fees, slower decision making, and the greater difficulty in dissolving the business.

The costs of incorporation must be weighed against the benefits to be derived. Roughly, tax savings are not likely to be realized unless each principal member has a taxable income of at least $12,000. Tax rates for small private companies as of January 1, 1972 are 25 percent on the first $50,000 of taxable income, and 50 percent thereafter, although the top rate is being reduced in stages to 46 percent. After a small private company has accumulated $400,000 in taxable income, the special low rate no longer applies.

Incorporation is somewhat more complex than other types of arrangements; therefore, it should be evaluated carefully with the assistance of legal, accounting, and agricultural economics advisors.

Rental Arrangements—Rental arrangements can help younger farmers to get started and are often a practical alternative for older farmers who need rental income after retirement. Rental arrangements can also be part of the father-son transfer process during a transitional period when the father acts as the landlord. Regardless of the personal situation in any one case, leasing always warrants thoughtful bargaining and attention to the details of the rental agreement.

Informal arrangements often provide an insufficient record and may not maintain a clear understanding of rights and responsibilities. Even short-term rental arrangements can have important effects on the welfare of farmer and landlord. Frank discussion and thoughtful bargaining, leading to a formal record of how the arrangement is intended to operate, are usually well worth the effort.

Livestock Leases—The suitability of a livestock-leasing arrangement depends on the terms negotiated and the individual situation. Before entering into a livestock-leasing arrangement, it is particularly important to give consideration to the quality of the management that might be expected, the fairness of the sharing ratio, and the adequacy of the terms that are to govern the arrangement. If either party is not satisfied with the lease, then it is not likely to be successful. Often it would be more advantageous for the tenant to purchase his own livestock breeding herd even if it is necessary to arrange for a loan.

The following example illustrates a suitable procedure for calculating an income-sharing ratio for a cow-calf livestock leasing arrangement.

Example: Livestock-Leasing Arrangement

The landlord supplies a breeding herd of 40 cows, a bull (or pays breeding costs), replaces breeding stock, receives full sales value of cull cows and bulls, and recovers his herd at termination.

The tenant provides all feed, pasture, housing, labor, veterinary, medicine, sprays, and other general services and costs required for maintaining a cow-calf operation.

Cow losses are replaced from natural increase, with the tenant responsible for raising the replacement. The landlord insures the bull or carries the risk of death loss. The calf crop is to be shared in proportion to each party's cost contributions.

The landlord and tenant are individually responsible for the trucking and marketing of livestock sold.

Example: Livestock-Leasing Arrangement

Annual Costs	Landlord's Costs	Tenant's Costs	Total Costs
Investment Cost—8% x $9,500	$ 760		$ 760
Replacement Cost* (40 Cows at $8; Bull at $100)	420		420
Supervision, Bull Insurance, Other	100		100
Feed—85 tons at $18/ton		$1,530	$1,530
Bedding—12 tons		100	100
Pasture—$15/head		615	615
Salt, Minerals, Vitamin A		100	100
Veterinary, Medicine, Sprays, Dehorning,		85	85
Machinery, Equipment, Water Supply, Building Costs		370	370
Labor		1,000	1,000
Total Contributions	$1,280	$3,800	$5,080
Shares	$\frac{1280}{5080} \times 100\% = 25\%$	$\frac{3800}{5080} \times 100\% = 75\%$	

*Replacement Cost = $\frac{\text{Beginning Value of Cow-Salvage Value}}{\text{Productive Years}} = \frac{\$250-\$200}{6} = \$8/\text{cow}$

The preceding example shows that a **one-quarter:three-quarters** share ratio (landlord and tenant respectively) is reasonable for this type of arrangement. Other share ratios would apply with different conditions such as purebred herds or if more costs such as feed or pasture were contributed by the landlord. Inputs which result in more efficient production such as minerals, salt, vitamin A, veterinary services, and medicine may be shared in the same ratio as the calf crop is split. This provides a further incentive for the tenant to carry out such practices.

Death losses in the cow herd require special consideration. Generally, losses are replaced from natural increase and the tenant is responsible for the cost of raising the animal. Since the tenant bears most of the cost of replacement, this may seem unfair where losses occur through no fault of his own. However, it does put the onus on the tenant to use management practices which keep death losses at a minimum. A modification to this approach would be to have the landlord absorb part of the cost of raising the replacement from weaning to breeding age.

Different methods may be used for the replacement of breeding stock. One alternative is that of raising replacements from natural increase. With this method, the tenant shares in the sale value of cull cows in the same proportion as the calf crop is split. However, it results in the tenant absorbing the total cost of raising replacements and consequently, his share of the income should be increased as compared to the example shown. A more equitable approach for the replacement of breeding stock is to have the landlord responsible for it and for him to receive the total proceeds from cull cows.

Method of Paying Rent

Share Rent—Share rent gives the landlord a claim on a share of the physical production. The uncertainties of production and markets are thereby shared by both parties.

The actual amount of share rent is determined by 1. the sharing ratio (⅓, ⅔, etc.); and 2. the amount of production available to be shared. Deciding on the share rent as some "fraction" of production is therefore only one part of the share-rent determination problem. The farmer's management affects the amount of production and thereby also affects the actual amount of share rent.

During discussions and bargaining for the amount of share rent, the farmer and landlord therefore need to consider the **farming practices to be followed** as well as the sharing ratio.

Customary share leases sometimes leave the farmer responsible for most or all of the operating costs. **An understanding that the farmer will follow particular farm practices at his own expense can be a legitimate part of the bargain between farmer and landlord.**

Cash Rent—A fixed cash rent gives the landlord the right to a cash payment, regardless of the uncertainties of production and markets. Cash rents are often preferred by landlords who want to avoid fluctuations in their rental income, and by farmers who desire a free hand regarding farming decisions.

Fixed cash rents are often unsuitable from the farmer's point of view unless: 1. They are sure of a ready market for the crops to be grown on rented land; or 2. the rented land is a small part of the whole farm; or 3. livestock provides some cash flow insurance for the farm unit.

Share-Cash Combination—A combination rent payment serves the needs of farmers and landlords when: 1. The landlord requires a minimum of cash to cover his own fixed-cash outlays; or 2. there are buildings or improvements used by the farmer which do not contribute directly to the production on which the share rent is based.

A combination share-cash rent tends to shift more uncertainties onto the farmer than if there were a straight share rent, and shifts more uncertainties onto the landlord than he would have under a straight cash rent.

Standing Rent—A standing rent refers to a fixed amount of production (in bushels or head) which the landlord receives each year as rent.

A standing rent burdens the farmer with the uncertainties of production, but the landlord shares in the uncertainty of market quotas or prices.

The landlord receives a fixed amount of produce, but its value would vary from year to year depending on when he could sell it and on the price at which it can be sold.

Standing rents, like combination share-cash rents, represent a type of compromise between an ordinary share rent and a fixed-cash rent.

Negotiating Rental Terms

Any question which represents a potential source of uncertainty regarding the rights and responsibilities of farmer and landlord should be discussed at the time the original agreement is made. The uncertainties should be resolved by **discussion** and **written agreement** on specific provisions.

The parties to all types of leases should consider the need for provisions which clarify the rights and responsibilities of each party with regard to the following points.

1. All Leases

- — description of property to be rented
- — length of the lease
- — procedures required for renewal
- — procedure for renegotiation of provisions of a long-term lease
- — amount of rent and how it is to be paid
- — division of expenses for repairs to improvements
- — right of farmer to remove improvements
- — compensation to farmer for expenditures on permanent improvements
- — responsibility for taxes
- — amount of summerfallow required at termination
- — compensation per acre if there is more or less summerfallow than required at termination
- — rights, responsibilities, and compensation for removing stones, clearing, or breaking
- — rights to assign benefits under the lease to others
- — restrictions and responsibilities regarding production practices and management decisions.

2. Additional Points for Crop-Share Leases

- — restrictions and responsibilities regarding crops to be grown
- — share of crops to be earned as rent by the landlord
- — place(s) of delivery of landlord's share
- — responsibility for storing and hauling landlord's grain
- — responsibility for temporary grain storage
- — place of storage for landlord's grain
- — procedure for clear distinction between grain inventory owned by the landlord and that owned by the farmer
- — restrictions or responsibilities for farm practices
- — procedure (if any) for sharing costs of cropping inputs
- — procedures for specifying acres for Canadian wheat board quota purposes
- — procedures for handling problems related to the Prairie Grain Stabilization Plan or other governmental programs.

3. Additional Points for Livestock-Share Leases

- — brands, tags, marks, weights, and ages of cows
- — share of calves to be earned as rent by the landlord
- — responsibility of compensation for marketing calves
- — dates for breeding and weaning
- — procedures and responsibilities for culling cows and replacement with younger stock
- — responsibility for insurance on the herd
- — landlord's right to be notified given particular conditions
- — procedures (if any) for sharing costs of veterinary services and medicines, vitamins and minerals, etc.
- — responsibilities for production decisions, e.g., pasture creep feeding, dehorning, castration, type and amount of winter feed, etc.

4. Additional Points for Cash-Rent Leases

- — date(s) on which rent payment is due
- — special rights of the parties if rent is in arrears
- — flexibility formulae and how a formula will operate if used.

CREDIT USE AND SOURCES

Making the Best Use of Credit

A farm business requires the use of large amounts of capital in the form of assets such as land, buildings, breeding stock, and equipment, as well as operating funds for feeder cattle, fertilizer, fuel, taxes, repairs, and so on.

Savings usually accumulate too slowly to adequately provide funds; hence, the use of borrowed funds is essential to a thriving business. Credit should be used only where the increased returns will more than cover the cost of borrowing. It costs very little extra to use borrowed funds rather than one's own funds, and the funds are put to work sooner. Debt repayment on land should be looked upon as a savings or investment program.

Steps toward appropriate credit use include:

1. Any investment, made with one's own or borrowed funds, must be profitable. Project the expected income and expenses as a result of the investment.

2. Use credit wherever it promises to return more than its cost. If credit is limited, the amount available should be invested where it will give the highest returns. Project different alternatives to compare the profitability of each.

3. Repayment terms should coincide with repayment capacity. Once one has decided upon the amount of payment the business will generate, the appropriate length of repayment can be determined from Table I.

Loans of less than 5 years are normally repaid at a fixed principal each year plus interest on the unpaid balance. Table II indicates the annual payment on a 5-year loan.

TABLE I
Annual Principal and Interest Payment Required Per $1,000 of Original Debt
(Amortized Basis) *

Interest Rate	Repayment Period (Years)							
	5	10	15	20	25	30	35	40
5%	$230.97	$129.50	$ 96.34	$ 80.24	$ 70.95	$ 65.05	$ 61.07	$ 58.28
6%	237.40	135.87	102.96	87.18	78.23	72.65	68.97	66.46
7%	243.89	142.38	109.79	94.39	85.81	80.59	77.23	75.01
8%	250.46	149.03	116.83	101.85	93.68	88.83	85.80	83.86
9%	257.09	155.82	124.06	109.54	101.81	97.34	94.64	92.96
10%	263.80	162.75	131.47	117.46	110.17	106.08	103.69	102.26

*"Amortized basis" means the payments per year are equal: the first few, therefore, include more interest and less principal than later payments. Unamortized loans will require larger payments the first few years.
Example: $12,000 loan, 15-year repayment period, 8% interest rate.
Annual Payment = 12 x $116.83 = $1,401.96.

TABLE II
Annual Principal and Interest Payments Per $1,000 of Original Debt
(1/5 of principal plus interest on unpaid balance due the end of each year)

Interest Rate	Year 1	Year 2	Year 3	Year 4	Year 5
5	$250	$240	$230	$220	$210
6	260	248	236	224	212
7	270	256	242	228	214
8	280	264	248	232	216
9	290	272	254	236	218
10	300	280	260	240	220

4. The debt limit of your business will depend on your expected income and expenses—both personal and business expenses. Having determined your annual repayment capacity, one can use Table III to give an indication of your debt limit.

TABLE III
Debt Limits Per $100 Annual Payment Capacity
(Amortized Basis)

Interest Rate	Repayment Period (Years)							
	5	10	15	20	25	30	35	40
5%	$433	$772	$1,038	$1,246	$1,409	$1,537	$1,637	$1,716
6%	421	736	971	1,147	1,278	1,376	1,450	1,505
7%	410	702	911	1,059	1,165	1,241	1,295	1,333
8%	400	671	856	982	1,067	1,133	1,165	1,192
9%	389	642	806	913	982	1,027	1,057	1,076
10%	379	614	761	851	908	943	964	978

Example: $1,500 annual payment, 25-year repayment period, 8% interest rate.
Debt limit = 15 x 1,067 = $16,005.
This means that if a farmer can make a $1,500 payment each year, he can carry a loan of $16,000 over a 25-year repayment period at 8% interest.

5. Compare not only interest rates but terms, down-payment requirements, and other services from various sources, and select the most appropriate source.

6. Loans other than those for real estate should be consolidated under one source, if possible. The lender will be in a better position to provide adequate funds and will be more tolerant of unforeseen problems such as hail, disease, or other calamities.

7. Prepare a balance sheet or statement of your current assets and liabilities to present to your lender.

8. Be frank, honest, and businesslike in your approach to the lender.

9. See the local representative of the lending agency.

Establishing the Cost of Credit

Like any other item one buys, the cost of money is an important consideration, but not the only factor to consider. Repayment terms, security requirements, and an understanding lender may be more important than interest rates.

Interest rates vary with the purpose of the loan, length

Summary of Farm Credit Sources

Lending Agency—Interest Rates as of September 28, 1971	Types of Credit and Purposes	Borrower Qualifications: Loan Terms
Farm Credit Corporation (F.C.C.): Farm Credit Act. Interest rate—7½% per annum. Interest rates set semi-annually. Appraisal fee $10 plus $2.00 to $2.50/$1,000 of loan. Life insurance available.	Long and intermediate term credit to provide essential capital for a viable farm unit. Loans for land and improvements, stock and equipment, discharge of liabilities, or other productive purposes.	Loans to persons principally occupied in farming. Up to 30-year repayment terms. Equal annual or semi-annual instalments of principal and interest. First mortgage security. Maximum of $100,000 for partnerships, co-op farms and corporate farms. Part II—$40,000 for each qualifying farmer or 75% of appraised value, whichever is the lesser. Part III—(1) Lesser of $55,000 or 75% of appraised value of land and chattels, for applicants 21-45 years of age. (2) Lesser of $55,000 or 90% of appraised value of land and chattels, provided the farm will be operated at a high level of efficiency, for applicants 21-35 years of age.
Farm Credit Corporation: Farm Syndicates Credit Act. Interest rate—6¾% per annum. Interest based on cost of funds to Corporation.	Loans to "syndicate," groups of 3 or more farmers for co-operative purchase and use of farm machinery, buildings, or installed equipment.	Loans up to 80% of cost. Can be up to $15,000 per farmer or $100,000, whichever is the lesser. Repayment term up to 7 years.
Veterans' Land of Administration (V.L.A.): Part I—3½% interest per annum. Part III—7½% interest per annum. Interest rates set semi-annually for new loans.	Loans under either part available for purchase of land, equipment, stock, erection or improvement of buildings, clearing and breaking land, irrigation drainage, fencing, and debt consolidation.	Applicants must have qualified as veterans by October 31, 1968, and must apply before March 31, 1974. Part I—$6,000 maximum (not more than $1,200 for equipment and stock). Repayment period—up to 30 years. Part III—Maximum of 75% security value of land, equipment, and basic herd up to limit of $40,000. (The limit is reduced by any outstanding indebtedness under Part I.) Repayment term—up to 30 years.
Saskatchewan Economic Development Corporation (SEDCO): 9% interest rate to vary with money market.	Loans for intensive agricultural enterprises in which investment is centred in fixed assets other than land, e.g., hog barns, poultry barns, feedlots, etc.	Loan amounts normally up to 50% of market value of fixed assets pledged. Repayment term normally up to 10 years, monthly instalments of principal plus interest.
Chartered Banks: Minimum of 7% interest.	Short- and intermediate term credit for virtually all farm needs.	Amount depends on profitability of the business and security offered. Terms vary with the purpose of loan.
Credit Unions: Interest 7% to 12% per annum. Loans life insured in most cases.	Short- and intermediate-term credit for a variety of farm credit needs.	Amount of loan depends on credit rating and outstanding indebtedness of borrower. Security taken on land and chattels.
Farm Improvement Loans Act: (Available from chartered banks and credit unions.) Interest rate 7½% for land, interest rate 6¾% for other purposes. Rate to vary with money market—set semi-annually.	Government-guaranteed loans for items related to the improvement of the farm (implements, buildings, breeding stock, clearing, land purchase).	Maximum loan $15,000 for either land or other purposes and a maximum total loan of $25,000. Repayment period up to 15 years for land. Others up to 10 years depending on the purpose
Insurance, Mortgage, Trust Companies: Interest—9% rate to vary with money market.	Longer term loans on real estate.	Amount depends on credit rating and security value.
Industrial Development Bank (I.D.B.): Interest currently 9½% minimum and varies with money market.	Medium term (5-15 years) for purchase of fixed assets, working capital, establishment of new business, change of ownership, etc.	Loans to Canadian businesses, including agriculture, where funds are not available from other sources, or government lending agencies. Loan amounts and repayment terms based on security available and earning capacity.

of repayment, profitability of the business, and the lending agency. Just as some farmers get a better buy on an implement, some are able to obtain money at a lower cost. Some are able to sell their plan because adequate records reveal their past performance and they have carefully projected costs and returns for their plan.

A projection should include the amount of capital outlay required for each purpose (land, buildings, machinery, and livestock) together with expected expenses and receipts that reveal the repayment capacity of your business. It should also include a cash flow, especially during the transition period while implementing the plan.

Most commercial lenders now reveal the actual simple interest rate on their loans. Additional charges are sometimes collected for legal fees, servicing the account, and insurance. It may be wise to carry insurance separate from loans to meet the entire insurance needs of the operator.

Firms selling products to farmers often allow them to charge the purchase. Such agreements usually fall into the instalment or retail-credit area where finance charges may be quite high. The best way to compare the cost of various types of loans is to convert the total finance charges to an actual interest rate. The following formula can be used to approximate the actual interest rate on shorter term loans.

$$\text{Actual Interest Rate} = \frac{2X \text{ (Number of Payment in a Year)} \times \text{(Finance Charges)}}{\text{Amount of Loan} \times \text{(Total Number of Payments} + 1)}$$

Finance charges are arrived at by adding up the total of all payments and fees, except the down payment, and subtracting the original amount of the loan.

PURCHASING FARMLAND

The purchase of farmland is a decision with major repercussions for most farmers. This one decision may greatly affect an individual's net income and debt commitment for many years.

It is difficult to devise formulae which can accurately suggest the correct amount which one should pay for land. Detailed consideration would need to be given to the uncertainties of production and marketing on a long-term basis and to the capabilities of the individual involved. This implies that individuals have various capacities in paying land debts. This occurs because of the circumstances under which these individuals operate. Individuals adding a unit to an existing economic unit, and those investing for speculative purposes will tend to be more competitive than those attempting to develop an economic unit.

Many individuals buying land do so in anticipation that the income flow generated by the land will meet the loan repayment, operating expenses, and leave a residual to the operator's labor and management. The loan-repayment schedule can vary widely as demonstrated in Table IV.

TABLE IV
Annual Principal and Interest Payment Per Acre on Land Purchased Under Various Conditions
(Amortized Basis—25 Years)

Interest Rate	Purchase Price Per Acre							
	$40	$60	$80	$100	$120	$140	$160	$180
5%	2.84	4.26	5.68	7.10	8.52	9.94	11.36	12.78
6%	3.13	4.69	6.26	7.82	9.38	10.95	12.51	14.08
7%	3.43	5.15	6.86	8.58	10.30	12.01	13.73	15.44
8%	3.75	5.62	7.50	9.37	11.24	13.12	14.99	16.87
9%	4.07	6.11	8.14	10.18	12.22	14.25	16.29	18.32
10%	4.41	6.61	8.82	11.02	13.22	15.43	17.63	19.84

It should be recognized that the principal portion of the above land payment represents a form of savings for the individual. However, even though this payment increases the net worth of the individual, it removes cash from the individual for an extended period. A 25-year repayment schedule represents a major portion of an operator's farming career, so an individual must be prepared for this cash outflow commitment for most of his active farming days.

Prior to the purchase of farmland, an individual must determine if such a move is economically feasible.

To do this, he must consider the circumstance of his operation and attempt to estimate costs and returns for an extended future time period. The procedure outlined here suggests that the excess of income over expenses will dictate how much one can afford to pay per acre for land when faced with a particular interest rate. An example of such a calculation is given below:

Example: Calculating Amount Available for Annual Land Payments

Value of grain production:		
½ x 28 bu/ac = 14 bu/cultivated ac	$1.35/bu	= $18.90/ac
Cash Costs and Hired Labor	$5.00	
Seed—½ x $2.00/ac	1.00	
Depreciation—Buildings and Machinery	2.50	
Investment Cost—Buildings and Machinery	1.50	
Operator and Family Labor	3.00	
Total Less Land Investment Cost		$13.00/ac
Amount available for annual land payments		$ 5.90/ac

Assuming an interest rate of 7 percent, the amortization payments outlined in Table IV indicate that an annual payment of $5.90 per acre would permit paying not more than $70 per acre for land. If more than $70 per acre was paid for land in this example, the additional payment required would need to come from savings, from other sources of income, or from reductions in family and operator labor returns.

In the example, it was assumed that all of the grain produced was sold. A restricted marketing situation which forces some of this production to remain unsold will create difficulties in meeting the cash outlay shown in the example. Producers purchasing land must be prepared for this eventuality.

INCOME TAX MANAGEMENT

Tax management is important because of the impact of taxes on income and their effect on estates. Taxation management requires a knowledge of both tax regulations and farm-planning procedures. Because of frequent changes in legislation and regulations regarding tax provisions, farmers should consult the tax department offices in their area if problems or questions arise. The federal income tax offices at Regina or Saskatoon, or private tax consultants should be consulted for further details.

The federal government has proposed to abandon the areas of gift tax and estate tax. New provisions are not available at the time of printing the **Guide.** Estate plans should be carefully considered in light of whatever changes do exist.

Income Tax

The objective of income tax management is not to pay the smallest amount of tax over a period of years but to attain the maximum net income after taxes. If management decisions are made and business is transacted solely in an effort to reduce taxes, net income after taxes may actually be reduced.

Successful tax management requires that complete records be kept. Income tax should not be a once-a-year consideration; the tax payable at the end of the year is determined by decisions made over a period of time. Farmers, therefore, need to know enough about income tax regulations to recognize the influence of these decisions.

In general, the 5-year averaging alternative should be used by farmers to level out taxable income. Farmers holding back sales or prepaying expenses to average taxable income on an annual basis should consider the interest returns which they give up because of such transactions. The timing of sales and purchases should be aimed at obtaining the highest possible income from the farm.

In the past, the Part XVII Method of taking capital cost allowance was generally preferred to the Part XI Method because of the possibility of getting tax-free capital gains. Current tax revisions must be viewed as they become

available. It appears that the Part XVII Method will be phased out and everyone will use the Part XI Method for capital cost allowance.

To take advantage of the provisions of the Income Tax Act, farmers should consider such things as all allowable expenses and personal exemptions, recovery of business losses, use of the 5-year average where applicable, and use of basic herd provisions. Current proposals include removing the basic herd provision.

Canada Pension Plan

The Canada Pension Plan (C.P.P.) is a social insurance program whereby each person receives benefits according to contributions made during his working lifetime. It should be understood that the C.P.P. is entirely separate from the Old Age Pension Plan and individuals may receive both pensions. The following outlines some of the main features of the Canada Pension Plan.

1. The C.P.P. is compulsory for all persons between ages 18 and 65 unless exempt because of insufficient income ($800 for farmers; $600 for others).
2. C.P.P. contributions are based on "Net Farm Income" as defined for income tax filing requirements. Rental and investment income is not included for C.P.P. purposes. The maximum income on which C.P.P. contributions can be made is $5,400 and maximum total contributions are $86.40 per year.
3. Farmers are required to make contributions on behalf of employees who are employed by them for at least 25 days and also earn more than $250 cash wages in a calendar year. The employer and employee share equally in the contributions (1.8 percent by each party).
4. Farmers contribute to the Plan when they file their income tax returns. Self-employed persons such as farmers pay the whole share of the contribution (3.6 percent).
5. Both premiums and benefits will change as the cost of living changes.
6. Three main types of benefits are included: Retirement pensions; disability pensions; survivor's benefits. After the initial 10-year period of the C.P.P., a retirement pension will be based on 25 percent of the average annual earnings.
7. Canada Pension Plan contributions by farmers may involve certain management considerations. For example, farm income cannot be averaged for C.P.P. purposes, and rental income cannot be included.
8. Adequate records are essential, since many farmers will have to file returns for C.P.P. requirements even though they may not be taxable.
9. Farmers with hired help should contact their district taxation office to obtain the necessary forms for meeting C.P.P. requirements. It is necessary to give (or obtain) the employee's social insurance number, submit regular contributions, and to complete year-end T4 Supplementary and T4 Summary forms for employees.
10. Additional information can be obtained from bulletins prepared on the Canada Pension Plan, and by contacting district taxation offices of the Department of National Revenue (re: enforcement) or the Department of Health and Welfare (re: benefits).

Unemployment Insurance

The following outlines some of the main features of unemployment insurance as it relates to hired farm labor.

1. Participation in the unemployment insurance scheme is compulsory unless: The employee is a close relative; the employee earns less than $250 cash wages and works less than 25 days in a calendar year for a particular employer; or other situations which make an employee ineligible. Check with the Unemployment Insurance Commission.
2. Farmers having eligible employees must register as employers with the Unemployment Insurance Commission.
3. When hiring an eligible employee, a farmer must obtain his unemployment insurance book or apply to the Commission for a book if the employee does not have one. It will be necessary to provide the employee's full name, his social insurance number (or apply for one), and date of birth.
4. If you have an employee who becomes insurable while working for you, it is necessary to register with the Commission within 3 days after the employee becomes insurable.
5. The farmer and employee contribute equally to the cost of unemployment insurance.
6. Generally an employee must have contributed for at least 8 weeks before he is eligible for benefits.
7. The farmer is required to keep detailed records as to the names and addresses of employees, social insurance numbers, period employed, gross wages, deductions from wages, etc.
8. The local unemployment insurance office should be contacted for more detailed information and requirements.

CROP INSURANCE

A government program to provide all-risk crop insurance was started in Saskatchewan in 1960. By 1968 the number of insured farmers had reached 12,343. The Crop Insurance Board is continuing to expand the program as demand and interest grow. It is an important program for farmers who wish to protect the large investment they have in their crops, and is also important to the communities in which they live, to the extent that farm incomes are made more stable and secure. Crop insurance is a voluntary program.

To protect income and savings against crop losses, crop insurance provides protection against virtually all causes of risk beyond the farmers' control (including drought, flood, hail, frost, wind, lightning, wild life, snow, insects, plant disease, excessive rain, hurricane, tornado). The program guarantees to an individual farmer the value of a specific number of bushels of each crop insured on his farm. The farmer has a choice of the price level at which he wants this bushel coverage valued. A farmer has a claim if the number of bushels produced is less than his guarantee.

Crops that can be insured include spring wheat, durum wheat, barley, oats, rapeseed, and flax. In 1972 crop insurance will be offered in practically all areas of Saskatchewan where there is sufficient interest and administrative arrangements can be completed. Each area has a crop insurance agent who has detailed information about coverages on a quarter-section basis, premium rates, discount provisions, and so on. Only owner-operators or tenant-operators can insure directly with the Board. Landlords may make arrangements with tenants to share premiums and indemnities.

The amount of insurance a farmer can purchase is determined by his acreage of insurable crops and the price options he selects. All insurance contracts are on an individual farm basis. Each crop is insured separately and losses are adjusted on a per-crop basis. Although crop insurance protects against hail damage, it is advisable in many cases for farmers to also purchase additional hail insurance.

All administrative costs are shared equally by the governments of Canada and Saskatchewan. The Government of Canada also pays 25 percent of the necessary premiums, so the farmer pays only 75 percent of necessary premiums and no part of the administration costs. Canada and Saskatchewan also share in a reinsurance program to protect the program against losses in excess of premiums and reserves in the Crop Insurance Fund. The program is administered by the Government of Saskatchewan.

Additional information on crop insurance is available from crop insurance agents or the Saskatchewan Crop Insurance Board, Regina.

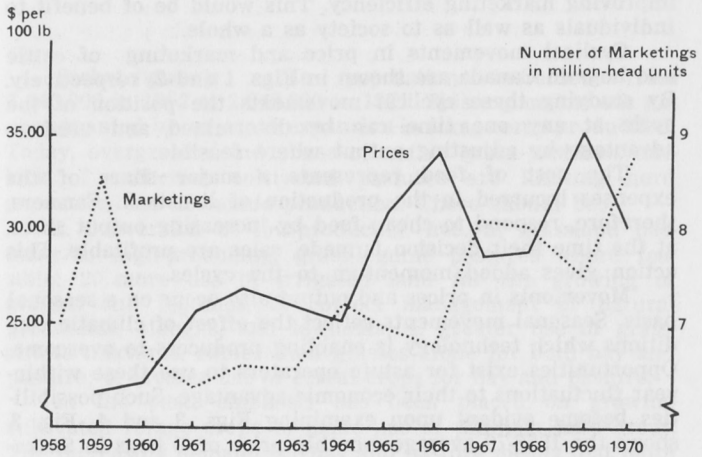


Fig. 1—Weighted average prices and marketings of B-Dressed hogs at public stockyards, Canada, 1958-1970

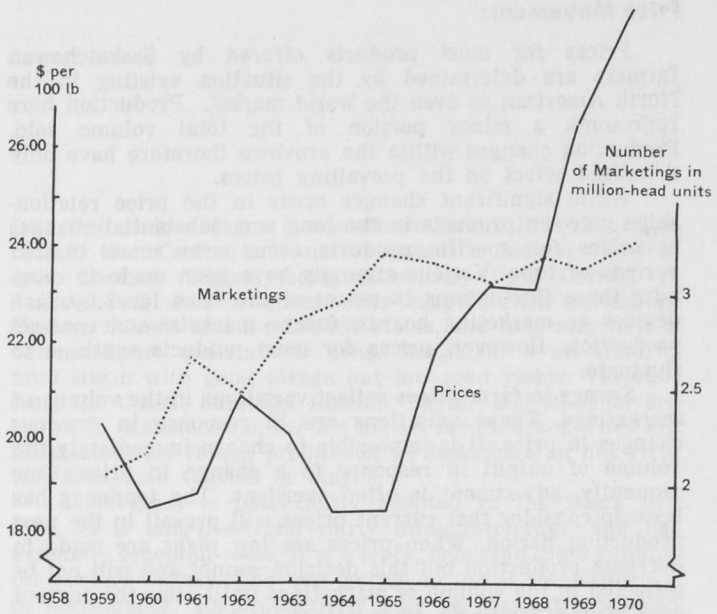


Fig. 2—Weighted average prices and marketings of cattle at public stockyards, 1958-1970

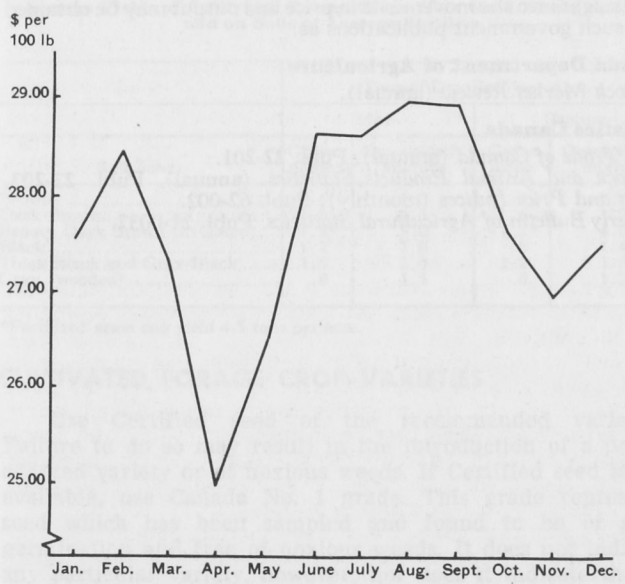


Fig. 3—Average monthly prices of B-Dressed hogs, Saskatoon, 1961-1970

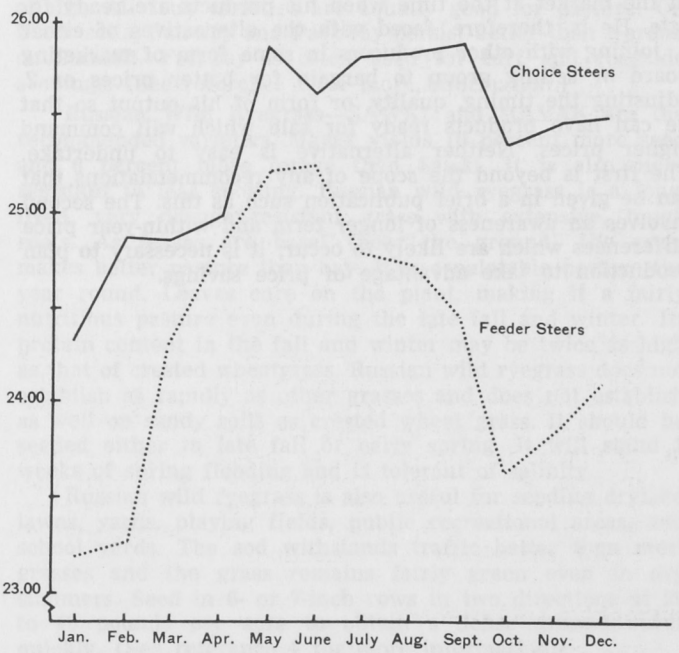


Fig. 4—Average monthly prices of choice and feeder steers, Saskatoon, 1961-1970

MARKETING

Price Movements

Prices for most products offered by Saskatchewan farmers are determined by the situation existing in the North American or even the world market. Production here represents a minor portion of the total volume sold. Production changes within the province therefore have only a limited effect on the prevailing prices.

While significant changes occur in the price relationships between products in the long run, substantial changes in prices for specific products occur over more limited periods of time. Various attempts have been made to minimize these fluctuations in prices at the farm level by such devices as marketing boards, future markets, and contract production. However, prices for most products continue to fluctuate.

Swings in farm prices reflect variations in the volume of marketings. These variations are in response to previous changes in price. It is impossible to change immediately the volume of output in response to a change in price. Consequently, adjustment is often overdone. The tendency has been to consider that current prices will prevail in the next production period. When prices are low plans are made to decrease production but this decision cannot and will not be reflected in the volume of marketings until after the current crop is sold. Similarly, when prices are high plans are made to increase output but the subsequent increase in the volume of marketings will be delayed by a time covering at least one growing period. The span of these fluctuations, called cycles, therefore varies from product to product. A 2-year production cycle is present in eggs, a cycle of from 3 to 4 years in hogs, 8 to 10 years for cattle, while for many crops the cycle spans a maximum of 2 years.

Using Price as a Guide to Production

The individual producer acting alone on his own farm is in the position of having to accept the price that is ruling in the market at the time when his products are ready for sale. He is, therefore, faced with the alternatives of either 1. joining with other producers in some form of marketing board or selling group to bargain for better prices or 2. adjusting the timing, quality, or form of his output so that he can have products ready for sale which will command higher prices. Neither alternative is easy to undertake. The first is beyond the scope of any recommendations that can be given in a brief publication such as this. The second involves an awareness of longer term and within-year price differences which are likely to occur; it is necessary to plan production to take advantage of price savings.

To a large extent this means that the producer must become aware of any large swings in production being undertaken by other producers. He might then be able to operate against these trends. To the extent that flexible production plans are economically feasible it is possible to operate in an independent fashion so that volume sales are made in attractive price periods. If this action became general the cyclical fluctuations would be reduced, thereby improving marketing efficiency. This would be of benefit to individuals as well as to society as a whole.

Cyclical movements in price and marketing of cattle and hogs in Canada are shown in Figs. 1 and 2, respectively. By studying these cyclical movements the position of the cycle at any one time can be determined and used to advantage by adjusting output where feasible.

The cost of feed represents a major share of the expenses incurred in the production of livestock. Farmers, therefore, respond to cheap feed by increasing output since, at the time their decision is made, sales are profitable. This action gives added momentum to the cycles.

Movements in prices and output also occur on a seasonal basis. Seasonal movements reflect the effect of climatic conditions which technology is enabling producers to overcome. Opportunities exist for astute operators to use these within-year fluctuations to their economic advantage. Such possibilities become evident upon examining Figs. 3 and 4. Fig. 3 shows the 1958-70 average monthly price of B hogs in Saskatoon. On the average, hog prices have been highest during June, July, and August. Hogs marketed during this period would need to be farrowed in the December-February period so would incur the costs of winter production. Fig. 4 shows that the price of choice steers in Saskatoon during 1958-70 was highest during September and December, and lowest in February and March. The price of feeder steers, on the other hand, was highest in April and May and lowest in January. Assuming a 6-month feeding period, the greatest margin between the price of choice slaughter steers and good feeder steers occurs when steers are sold in July and August.

REFERENCES

Insight into the movements in price and output may be obtained from such government publications as:

Canada Department of Agriculture

Livestock Market Review (annual).

Statistics Canada

Grain Trade of Canada (annual). Publ. 22-201.
Livestock and Animal Products Statistics (annual). Publ. 23-203.
Prices and Price Indices (monthly). Publ. 62-002.
Quarterly Bulletin of Agricultural Statistics. Publ. 21-0032.

FORAGE CROPS (For figures, see color section, page 85.)

Saskatchewan's cattle population increased from 1,443,000 in 1952 to 2,643,000 in 1971. This expansion was not accompanied by an equal expansion in forage crop production. Today, overgrazing and abuse of native grass pastures, and lack of sufficient cultivated pastures are limiting herd expansion and economic production. There should be:

1. Conversion of low-producing, natural grassland pastures to high-producing, grass-legume pastures where feasible; 2. more use of irrigated land for the growing of grasses and legumes; 3. correct management of natural grasslands, sloughs, and lowlands; 4. greater use of grass-alfalfa mixtures, rather than grasses alone for both hay and pasture; 5. greater use of cereal crops for hay and pasture.

In the past, emphasis has been placed on growing cultivated forage crops to make use of problem land areas. The increasing demand for hay and pasture means that more good-quality cropland must be seeded to cultivated forage crops. These crops, selected for the rigorous climate of Saskatchewan, must be winter-hardy, persistent and, in the plains area, very drought resistant.

The average yields of grasses and grass-alfalfa mixtures that can be expected in various parts of Saskatchewan are given in Table I. Yields may be much higher or lower than indicated, depending on weather conditions. In the Brown and Dark Brown soil zones in particular, yields are variable. In these zones forage reserves should be provided or some summerfallow should be seeded each year to oats, or fall rye; otherwise, fodder may have to be purchased in drought years.

TABLE I

Average Yields of Cultivated Forage Crops With Good Management and on Soils of Average Fertility

	Tons of Dry Feed per Acre			
	Hay		Pasture	
Soil Zone	Grass alone	Grass-alfalfa mixture	Grass alone	Grass-alfalfa mixture
Brown	.6	1.0	.4	.6
Dark Brown	1.0	1.3	.6	.9
Brown, Dark Brown (irrigated)	1.5*	5.0	1.2*	4.0
Black	1.2	1.6	.8	1.4
Thick Black and Gray-Black	1.5	2.0	1.2	1.8
Gray (wooded)	.8	1.5	.6	1.2

*Fertilized grass can yield 4-5 tons per acre.

CULTIVATED FORAGE CROP VARIETIES

Use Certified seed of the recommended varieties. Failure to do so may result in the introduction of a poorly adapted variety or of noxious weeds. If Certified seed is not available, use Canada No. 1 grade. This grade represents seed which has been sampled and found to be of good germination and free of noxious weeds. It does not indicate any particular variety, however; nor does it indicate that it was produced on an inspected field. Blends being offered by some seed companies are an unknown quantity and cannot be recommended.

Perennial Grasses (See Tables II, III, and IV for recommended forage crops and mixtures)

Bromegrass—CARLTON and MAGNA are the recommended varieties. Carlton is a northern strain giving excellent seed yields. Magna is a southern strain. It is taller and coarser than Carlton and more resistant to lodging and leaf spot diseases. Magna yields more hay than Carlton in Saskatchewan and is much better adapted than Carlton in Eastern Canada and the United States, and thus may have a better export demand for seed. Redpatch is an Ontario-bred strain with good forage but low seed yields. Varieties from the U.S.A., Saratoga, Lincoln, Baylor, and Manchar are grown in Saskatchewan for the export seed market. They are satisfactory for forage production in Saskatchewan but yield less seed than Carlton or Magna.

Bromegrass is particularly adapted to the Black soil zone. It is long-lived and fairly drought-tolerant, and has extensive creeping roots. It is a leafy, palatable grass suitable for pasture or hay. The best period to use it for pasture is in midsummer. Its productivity may be markedly reduced by heavy spring use. It stands up to 3 weeks of spring flooding and is tolerant of moderately saline conditions. (See references 2 and 3 for more information.)

Crested Wheatgrass—FAIRWAY, PARKWAY, SUMMIT, and NORDAN are the recommended varieties. Crested wheatgrass is a very winter-hardy bunch grass that stands long drought periods. It is especially suitable for spring pasture and it makes good hay if cut shortly after heading and before flowering. Flooding for more than 1 week may reduce yields. It is tolerant of slightly saline conditions only. Parkway, Summit, and Nordan yield about 10 percent more hay than Fairway and are less competitive in mixture with alfalfa. All four varieties are equally good for pasture. On Black soils, Fairway and Parkway persist better than Nordan or Summit. Fairway is often used for turf and roadside seedings. (See reference 1 for more information.)

Russian Wild Ryegrass—SAWKI and MAYAK are the recommended varieties. Mayak yields 16 percent more seed and 6 percent more forage than Sawki. It is also more resistant to leaf spotting. Russian wild ryegrass is a long-lived, very drought-resistant grass with extensive, tough roots. As leaves are basal (near the ground) the grass makes better pasture than hay. It is a palatable pasture the year round. Leaves cure on the plant, making it a fairly nutritious pasture even during the late fall and winter. Its protein content in the fall and winter may be twice as high as that of crested wheatgrass. Russian wild ryegrass does not establish as rapidly as other grasses and does not establish as well on sandy soils as crested wheat grass. It should be seeded either in late fall or early spring. It will stand 2 weeks of spring flooding and is tolerant of salinity.

Russian wild ryegrass is also useful for seeding dryland lawns, yards, playing fields, public recreational areas, and school yards. The sod withstands traffic better than most grasses and the grass remains fairly green even in dry summers. Seed in 6- or 7-inch rows in two directions at 20 to 40 pounds per acre to obtain a dense ground cover quickly. (See reference 4 for more information.)

Intermediate Wheatgrass—CHIEF is the recommended variety. This is a tall creeping-rooted grass. It has large seeds and is easily established. This grass is highly productive on irrigated areas with good drainage. It is useful in most areas where bromegrass grows well, especially in short rotations, and gives best production in mixtures with alfalfa. GREENLEAF pubescent wheatgrass is very similar to intermediate wheatgrass and may be used in place of it.

Slender Wheatgrass—REVENUE and PRIMAR are the recommended varieties. Slender wheatgrass is a quick-establishing grass which can often be cut for hay the year of seeding. It will stand 5 weeks of flooding in the spring and is tolerant of severe salinity. Since it is quick to establish and short-lived (3 to 4 years) it is useful in short rotations. Revenue yields slightly more than Primar in all but the Brown soil zone.

Tall Wheatgrass—ORBIT is the recommended variety. This is a fairly long-lived bunch grass with coarse stems and leaves. It is a special-purpose grass for very saline soils that tend to be wet. Tall wheatgrass stands 3 to 4 weeks of flooding in the spring.

Reed Canarygrass—FRONTIER is the recommended variety. This is a tall, coarse, leafy grass with extensive creeping roots. The forage is coarse and not very palatable. Reed canarygrass withstands long periods of flooding (2 months or more in shallow water). It is useful in moist spring-flooded areas where better-quality grasses such as bromegrass would be killed out. It is long-lived in wet locations but on dry upland soils lasts only 1 to 2 years. (See reference 6 for more information.)

Streambank Wheatgrass—SODAR is the recommended variety. This is a special-purpose grass recommended for seeding ditch and canal banks, roadsides, public recreational areas, aircraft landing fields, and machinery yards. It has a strong creeping-root system which forms a dense smooth sod. It is adapted to all soil zones.

Timothy—BOUNTY, CHAMP, and CLIMAX are recommended for seed production. Timothy is not generally recommended for hay and pasture in Saskatchewan because it lacks drought resistance. However, in northern districts it is successful as a seed crop. It is a fairly short-lived bunch grass. It is tall, moderately leafy, and readily eaten by livestock. It stands up to 5 weeks of spring flooding but has little or no tolerance to saline (alkali) soil conditions.

Creeping Red Fescue—BOREAL is the recommended variety. This is a long-lived grass with creeping roots that form a dense sod. Since the leaves are mostly basal, it is used mainly for pasture or lawn. Creeping red fescue lacks drought resistance, so its use is limited to the Black and Gray soil zones and to watered lawns and irrigated pastures in other zones. (See reference 5 for more information.)

Kentucky Bluegrass—TROY, a United States' variety, was very productive in an irrigated pasture test at Swift Current and is recommended for trial in irrigated pastures.

Perennial and Biennial Legumes

Legumes differ from grasses in that they can use nitrogen from the air through the action of bacteria that live on nodules on the roots. Inoculation of seed with appropriate bacterial culture may be required in some districts to achieve maximum nitrogen fixation. (See reference 11.) If a deficiency of soil nitrogen develops, legumes yield more than grasses because they do not depend on the soil for their nitrogen supply. Legume hay generally contains more protein and vitamins than grass and thus is especially useful for young animals and milking cows. Bloat is not a serious hazard when pasturing legumes if the recommended mixtures are used and good management is practised.

Alfalfa—RAMBLER, ROAMER, BEAVER, DRYLANDER, and KANE are the recommended varieties. The last two were licensed in 1971 and Certified seed will not be available until 1973 or 1974. Alfalfa is a long-lived perennial with a deeply penetrating root. Rambler, Roamer, Drylander, and Kane are creeping-rooted (see Fig. 1, page 85) and much more drought-tolerant and winter-hardy than other varieties. Beaver, Roamer, and Kane have good resistance to bacterial wilt disease and Rambler and Drylander only partial resistance. Bacterial wilt may cause stand losses on irrigated land but seldom occurs on dryland. (See references 7, 8, and 9.)

Sweetclover—YUKON and POLARA are the recommended varieties. Sweetclover is a drought-resistant, hardy biennial. It is seeded in the spring, establishes that season, and produces a crop the next season. It withstands moderately saline conditions but will not survive over 1 week of flooding. Sweetclover is often used for silage or soil improvement in the northern part of the province. The sweetclover weevil is the major insect pest affecting sweetclover in Saskatchewan. (For cultural and chemical control recommendations, see Insect Pests section, page 109.)

Yukon is a winter-hardy, yellow-flowered strain which is well adapted to Western Canada. Polara is a low-coumarin strain of white-flowered sweetclover. Coumarin is a compound in ordinary sweetclover that is responsible for "Sweetclover Disease," which may develop when animals eat spoiled sweetclover hay or silage.

Red Clover—ALTASWEDE is the recommended variety. Red clover is generally not recommended for forage in Saskatchewan, as it is not completely winter-hardy. Altaswede (single-cut) is the most winter-hardy variety available. Lakeland is a double-cut variety commonly grown for seed. Other less hardy double-cut varieties are sometimes grown under contract for seed production.

Alsike Clover—AURORA is the recommended variety. Alsike clover is a short-lived perennial which reseeds itself readily. It is not drought-resistant and sometimes winterkills. It is the best legume to sow with grasses in wet meadows and peat bogs. Flooding tolerance of established stands in the spring is 14 to 21 days.

White Clover—(Commonly called White Dutch clover) MERIT and PILGRIM are the recommended varieties. It is an important legume for pasture in Southwestern Alberta but lacks winterhardiness in Saskatchewan and is generally not recommended. It is rather short, succulent, and spreads by underground rootstalks.

Sainfoin—MELROSE is the recommended variety. Sainfoin does not cause bloat. Thus it is an alternative to alfalfa or other bloat-inducing legumes. Under favorable conditions, Melrose will grow to a height of 3 feet or more, usually being taller than alfalfa. The stems tend to be coarse but remain succulent until well into maturity. Sainfoin is deep-rooted and, though fairly resistant to drought, it does best when moisture is plentiful. It will not persist in dryland pastures as well as alfalfa. It is not tolerant to flooding and does poorly on areas with a high water table. Melrose yields about as much hay as alfalfa when only one cut per season is harvested; however, if two or more cuts are taken it usually yields less than alfalfa. Growth starts very early in the spring and flowering occurs 10 to 14 days before alfalfa, sweetclover, or red clover. Sainfoin is a very attractive source of nectar and pollen, is pollinated by honeybees and wild bees, and sets seed readily. A special inoculant is required for sainfoin, and since it may be difficult to obtain it should be ordered well in advance of seeding. Certified seed of Melrose will be available for hay and pasture seedings by the spring of 1973. (See reference 10 for more information.)

Advantages of Grass-Legume Mixtures

See Tables II, III, and IV for recommended mixtures and seeding rates. See Table I for comparison of yields from grasses and grass-legume mixtures.

1. Grass-legume mixtures yield twice as much or more as grass alone (see Fig. 2, page 85); 2. a legume can use nitrogen from the air and when grown with grass will prevent a sod-bound condition from developing, and so prolongs the productive life of the stand; 3. grass-legume mixtures produce a better balanced feed; 4. compared with legumes alone, a mixture cures more easily; 5. there is less danger of bloat on a grass-legume pasture than on a straight legume pasture; 6. if the legume in a mixture winterkills, the grass will provide some hay or pasture until a new field can be seeded.

TABLE II

Recommended Forage Crops and Seeding Rates for Dryland

Soil Zone and Row Spacing	Crops (Use only recommended varieties)	Seeding Rate in lb/ac	
		Hay	Pasture**
Brown (18-24")	Russian wild ryegrass + alfalfa	—	3+1
(18-24")	Crested wheatgrass+alfalfa	3+1½ (alt. row) *	4+1
(18-24")	Alfalfa	4	—
(12" moist areas)	Bromegrass+alfalfa	5+2	5+1
(12" moist areas)	Intermediate wheatgrass+alfalfa	8+2	8+1
Dark Brown (12-18")	Russian wild ryegrass+alfalfa	—	6+1
	Crested wheatgrass+alfalfa	5+2	5+1
	Bromegrass+alfalfa	7+2	7+1
	Intermediate wheatgrass+alfalfa	8+2	8+1
	Alfalfa	6	—
	Sweetclover (seed in 6" rows)	10	—
Black, Gray-Black	Bromegrass+alfalfa	8+2	8+1
Black and Gray (wooded) (6-7")	Crested wheatgrass+alfalfa	7+2	7+1
	Intermediate wheatgrass+alfalfa	10+2	10+1
	Alfalfa	7	—
	Sweetclover	8	—
	Russian wild ryegrass	—	7
	Sainfoin	20-40	20-40

*See Fig. 3, page 85.

**If Sainfoin is used in place of alfalfa, seeding rate should be 20 pounds per acre.

TABLE III

Recommended Forage Crops for Irrigated Land

Soil Zones and Row Spacing	Crops (Use only recommended varieties)	Seeding Rate in lb/ac	
		Hay	Pasture
All Zones 6–7" Row Spacing	Alfalfa	10	—
	Sainfoin	30	30
	Troy bluegrass+alfalfa	—	10+3
	Bromegrass+alfalfa	12+3	12+3
	Intermediate wheatgrass+alfalfa	14+3	14+3
	Reed canarygrass+alfalfa	5+3	5+3
	Bromegrass+creeping red fescue+alfalfa	—	12+4+3

TABLE IV

Forage Crops for Saline Soils, Flooded Areas, and Peat
(6-7" row spacings)

Salinity rating*	Crop or Mixture	Seeding rate lb/ac for Hay or Pasture
	Soils with Little or No Spring Flooding (up to 2 weeks)	
Slight to moderate (2-6 mmhos.)	Bromegrass+Russian wild ryegrass+alfalfa (Rambler)	4+4+4
	Bromegrass+slender wheatgrass+alfalfa (Rambler)	4+4+4
	Slender wheatgrass+sweetclover (short-term stands and not over 1 week of flooding)	8+6
	Russian wild ryegrass+alfalfa	6+3
Severe (6-10 mmhos.)	Bromegrass+Russian wild ryegrass+slender wheatgrass	4+4+4
	Tall wheatgrass (moist districts or seepage areas)	12
Very severe (10-15 mmhos.)	Russian wild ryegrass+slender wheatgrass	4+4
	Tall wheatgrass (moist districts or seepage areas)	12
	Spring Flooded 2-5 Weeks	
Little or none (up to 2 mmhos.)	Reed canarygrass+bromegrass	4+6
	Reed canarygrass+timothy	4+4
	Timothy+bromegrass	4+6
Slight to moderate (2-6 mmhos.)	Reed canarygrass+bromegrass	4+6
	Reed canarygrass+bromegrass+slender wheatgrass	4+6+6
Severe to very severe (6-15 mmhos.)	Slender wheatgrass	8
	Tall wheatgrass	12
	Spring Flooded 5-8 Weeks	
Little or none (up to 2 mmhos.)	Reed canarygrass	5
	Reed canarygrass+timothy+slender wheatgrass	3+3+6
Slight to moderate (2-6 mmhos.)	Reed canarygrass, slender wheatgrass	4+6
	Tall wheatgrass	12
	Peat, Poorly Drained Soils	
Slight (0-2 mmhos.)	Timothy+alsike	5+2
	Timothy+bromegrass+slender wheatgrass+alsike	3+5+5+2
	Timothy+bromegrass+alsike	3+6+2
	Reed canarygrass+timothy	4+3

*Rating for salt content in millimhos per centimeter conductivity.

ANNUAL FORAGE CROPS

(See reference 23 for data obtained at Swift Current)

Cereals (See Grain Crops section for recommended varieties, page 63)

Mixtures of alfalfa and perennial grasses will yield as much hay or pasture over a period of years as cereal crops, and the costs of production are lower. However, cereals, and particularly oats, are excellent insurance crops for years when perennial crops fail because of drought. Oats should be seeded early and on summerfallow. Late and medium-late maturing varieties are more productive than early varieties. Maximum yield of cereals is reached at the dough stage. If harvested at the milk stage, however, yields

are only slightly lower, and the possibility of a second crop which will provide fall pasture is much greater. Nitrate poisoning from oat hay may be a problem, especially in dry seasons. (See Livestock section, page 149.)

Oats is a useful summer pasture, particularly in drought years, and may be used as alternate pasture while a perennial crop is being established. Allow up to 1½ acres of oats for each animal month of grazing and begin grazing at the shot-blade stage. If left longer, the crop may get ahead of the animals.

Fall rye makes a very useful early summer pasture.

Corn may be grown in central and southwestern districts on irrigated land. Silage is the main use of the crop, as the grain seldom matures. Early hybrid varieties, Morden 88, Morden 77, and Pride 116 have given 6 to 7 tons of dry matter per acre under irrigation at Outlook; but, at Swift Current, on clay soil the yields have been lower. Heavy fertilization and special weed control measures are essential for full production to be obtained. (See reference 24 for more information.)

Millet, sorghum, and sudan-grass hybrids are not recommended because they are inferior to oats as forage crops in Saskatchewan.

SEEDING PRACTICES

Stands of grasses and legumes on dry land should be uniform with at least one plant per square foot. Dense stands are not necessary. In the Brown and Dark Brown soil zones, grasses and alfalfa grown in rows 2 and 3 feet apart yield as much or more hay as when grown in rows 1 foot apart. (See reference 12.)

Condition of the Seed-Bed

The seed-bed, whether summerfallow or stubble land, must be firm. A firm seed-bed makes shallow seeding possible and provides better moisture conditions near the surface. Summerfallow and recently worked stubble land should be packed immediately after cultivation and seeded as soon as possible. Stubble land is usually firm enough if it is not worked before seeding. If seeding is done directly into stubble land, it is advisable to spray with an appropriate herbicide prior to seeding. (See Weed Control section, page 74.)

Row Arrangement

On dryland, forage rows should be seeded 18 to 24 inches apart in the Brown soil zone, 12 to 18 inches apart in the Dark Brown soil zone, and 6 or 7 inches apart in the Black and Gray soil zones.

Experiments at Swift Current show that seeding the grass and alfalfa in alternate rows in 18- or 24-inch spacings increases hay yields by 25 percent or more. (See Fig. 3, page 85.) Both the grasses and the legume establish more uniformly. This alternate row seeding can be accomplished by partitioning the drill box and thinning the alfalfa with cracked wheat or horticultural-grade vermiculite. Much the same benefit can be obtained by seeding grass in one direction and then cross seeding the field with alfalfa. In this case row spacings should be 24 inches apart. (See reference 12 for more information on row spacings of grasses.)

Depth of Seeding

Shallow seeding of grasses and legumes is essential to obtain satisfactory stands. Most grasses and legumes should be seeded about 1 inch deep. Very small seeded crops, such as Kentucky bluegrass and birdsfoot trefoil, must be seeded less than ½-inch deep. Sainfoin, in spite of its large seed, should be seeded less than ¾-inch deep. On firm land, shallow seeding can be accomplished with a grain drill if all pressure is taken off the discs. For even-depth shallow seeding, it is advisable to use depth-control attachments on the drill discs. (See Fig. 4, page 85.)

Spring Seeding

Spring seeding should be done before grain seeding becomes general. This is particularly important in the open prairie areas and on the light loams and sandy soils in all zones. In the moister areas, seeding may be left as late as June with reasonable chance of success. In northern areas, where spring frosts are hazardous, seeding of legumes should be delayed until June to escape frost damage.

In years and in areas where cutworms are a severe pest, it may be advisable to delay seeding alfalfa and sweetclover until early June to escape damage. Summerfallow should always be seeded in the spring.

Early Fall Seeding

Early fall seeding is recommended only when moisture conditions are good. Grasses may be seeded in late August or early September. Legumes must be seeded prior to August 15.

Late Fall Seeding

Late fall seeding just before freezeup helps to ensure germination early the following spring so that the young seedlings can take full advantage of moisture from the winter snowfall. Late fall is an excellent time to seed spring-flooded areas. All grasses and alfalfa, but not sweetclover, may be seeded in the late fall. Seeding into a cover of stubble or dead weeds is recommended.

New growth of winter annual weeds, such as flixweed or stinkweed, can damage fall seedings of forage crops through competition the next year. Spraying these weeds in the fall with 2,4-D will eliminate this competition. (See Weed Control section.)

Scarification

Sweetclover and birdsfoot trefoil seed will not germinate unless scarified. Scarification consists of chipping or cracking the seed coat. This is done by the seed companies prior to marketing the seed. When buying seed from neighbor farmers, make sure the seed has been scarified.

Companion Crops

Companion crops should not be used when seeding stubble land, but they may be used when seeding summerfallow. Drilling the companion crop first and then the forage crop separately and, if possible, crosswise, results in better stands than if both are sown together in the same drill rows. Sow the companion crop first at half normal rate and preferably through every other run of the drill or discer.

Wheat is the recommended companion crop because it is less competitive than other cereal grain crops. Oats may be used but it is advisable to swath the crop early for hay or silage to minimize competition.

In grasses grown for seed production a companion crop can be expected to reduce seed yields, especially under drought conditions.

On irrigated land, water should be applied immediately after the companion crop has been removed to give the forage crop a chance to make strong fall growth and accumulate adequate root reserves to survive the winter.

Methods of Seeding

Drilling—Drilling the seed into the soil is better than broadcasting. The press drill gives best results. Discers are

not recommended because they generally sow too deeply. Grass-seeder and depth-control attachments may be obtained for the grain drill to permit more accurate rate and depth of seeding. (See Fig. 3, page 85.) Every precaution must be taken to avoid seeding the forage crop too deeply.

For most grasses and mixtures, start with a setting of 1 bushel on the wheat scale, then try the drill on a hard surface. Count the number of seeds that drop per foot of row and then adjust the setting to seed 25 to 35 seeds per linear foot for 12- to 18-inch row spacings, and about 20 to 25 seeds per linear foot for 6- to 7-inch row spacings.

When seeding, the drill box should not be over one-half full or bridging may occur, causing the seed to stop flowing. A man should ride on the drill to watch the flow of seed and agitate the seed when bridging occurs.

It is difficult to drill a legume alone at the recommended rate, especially with old drills. Mix the seed with cracked grain from which the finer particles have been sifted out or use horticultural-grade vermiculite.

Broadcast Seeding—Broadcast seeding is sometimes practiced in areas of good rainfall and it may be used on rough ground or on very loose soil where the depth of seeding cannot be properly controlled. Small-seeded crops, such as alsike clover or timothy, may have to be broadcast because of the danger of seeding too deeply with a drill. Seed may be broadcast by a grain drill, with or without a fertilizer or grass-seed attachment, or by a tiller combine or discer. When the tiller combine or the discer is used the grain spouts should be removed entirely. A Cyclone broadcast seeder is useful for broadcasting seed on small areas.

All broadcast seedings should be made at a rate at least double that for drill seedings and should be followed by harrowing. Packing after harrowing is advisable.

Herbicides—(See Weed Control section, page 74.)

GENERAL MANAGEMENT OF GRASSES AND LEGUMES

The yields of perennial grasses decrease after the first 3 or 4 years if they are seeded without a legume and no fertilizer is used. Seeding grasses in a mixture with alfalfa will maintain yields at a high level. New fields should be seeded from time to time and old ones broken up and reseeded. Where this is not practical, old stands of most grasses may be made more productive by fertilizing. (See Soils and Fertilizers section, page 91.) Fertilizers. (See also Soils and Fertilizers section, page 92.)

Grasses

Nitrogen fertilizers will increase hay, pasture, and seed production of grasses. For pasture or hay, apply fertilizers in the fall or in the spring, for seed production early in the fall.

Legumes

Phosphate fertilizers will generally increase the yield of legumes. Sulfur-carrying fertilizers are required for legumes in the Gray soil zone, especially on sandy soils.

Grass-Legume Mixtures

For new stands on dryland fertilizers are not required, except in the Gray soil zone. On Gray soils, apply sulfur fertilizers as on pure legume stands. In other soil zones, where mixtures are over 3 years old and contain little legume, nitrogen fertilizers will generally give a marked response.

Grass-Legume Mixtures

On irrigated land, high rates of fertilizers will be required on stands over 3 years old.

Irrigation (See references 19, 20, and 21 for more information)

Forage mixtures and rates of seeding recommended for irrigated land are indicated in Table III. Heavy rates of fertilization are recommended with irrigation. (See Soils and Fertilizers section, page 93.)

Grass-legume mixtures for hay are among the most profitable crops to grow in Saskatchewan (except perhaps certain special crops). A yield of 4 tons of dry matter can be expected per acre from two cuttings. Seed production of grasses and legumes may also be profitable.

Irrigated pastures should be subdivided into three fields and the animals rotated between fields with an interval of 30 days between grazing. Grazing should begin in early May. A carrying capacity of two cows per acre for 120 days can be expected on productive stands on good irrigated pastures.

To realize maximum production from forage crops on irrigated land, it is important to irrigate early in the spring. Irrigate in May, when the growth of alfalfa is from 4 to 6 inches high. Early spring irrigation prevents the plants from stunting because of moisture deficiency. A general rule for irrigating forage crops: apply water around May 15, again around June 10 if rainfall is deficient, again after the first cutting around July 1, and after the second cutting around the end of August. Apply about 4 inches of water at each irrigation. (See Irrigation section for further information, page 36.)

Improving Sloughs and Meadows (See references 22 and 28)

Mixtures of grasses and legumes suitable for many of the varying conditions of flooding and salinity in low-lying areas are given in Table IV. Where there is considerable variation in time of flooding, the more complex mixtures should be used. It may be advisable first to break and seed a test strip through such an area.

Areas in unproductive native grass or sedge covers should be plowed and worked down into a good seed-bed before seeding. Seeding directly into native sod is not advisable, as the seeded crops take a long time to become established. A good practice is to grow a cereal the year after breaking and seed the forage into the stubble in late fall. Stony soils and peaty areas which cannot be plowed may be one-wayed deeply or worked well with heavy-duty cultivators. On very heavy soils, crusting may develop and prevent seedlings from emerging. On such soils late fall seeding is desirable. Otherwise, the seed should be broadcast in the spring and covered lightly. Seed of the recommended grasses (Table IV) will stand almost as much flooding as the native grass plants.

Peaty soils need special attention. Surface drainage is the first requirement. Heavy pasturing for a few years before breaking is beneficial, as the grazing animals pack and manure the soil. After breaking and before and after seeding, the peat should be heavily packed.

Under excess moisture conditions (rain or flooding), only limited grazing is advisable on sloughs and meadows, particularly those with heavy-textured soils seeded to tame grasses. Under these conditions, trampling by livestock will kill out the tame grasses and encourage the growth of such undesirable plants as wild barley.

Critical Period

Do not cut or graze alfalfa during the critical period from September 1 to October 15. Cutting in this critical period may result in winterkilling and reduced production the following year. At this time the plants store root reserves that are necessary for winter survival and vigorous growth in the spring. Cutting or pasturing in September or

early October may deplete root storage. Cutting in late October will not usually be followed by regrowth, but winter injury may result if the field does not hold an adequate snow cover. A late cutting (October 10 or later) may be taken, but it is often difficult to cure for hay, although it makes good silage. A high stubble should be left to catch snow.

Snow Conservation

Throughout the province, the hay yield of grasses and legumes has been increased up to 50 percent by snow conservation. Grasses and legumes respond to such treatment to a far greater extent than cereals. Leaving fall growth of alfalfa and grasses to catch snow is highly recommended, even if left only in strips through the field. The best implement to use for late fall cutting is a centre delivery swather.

Breaking Grassland

For soil improvement, forage crops should be left down for short periods, especially on the Thick Black, Gray-Black and Gray (wooded) soils. Substantial amounts of root fibre are built up in the soil during 3 or 4 years. Three-year-old stands of crested wheat or bromegrass will add about 2.5 tons of fibre per acre foot of soil and five-year-old stands about 3 tons.

For best kills and greatest moisture conservation, grasslands should be broken late in the fall if moisture conditions permit, left rough, and fallowed the following year. In the Black and Gray soil zones, a crop of hay may be taken and the field broken by July 15. The field should be fallowed the rest of the year.

Following the breaking of grasslands, wireworms may be a problem. They can be controlled by treatments on seed grain. Yields of cereals following cultivated grasses may be reduced for one or two crops. This is particularly noticeable following pure stands of bromegrass. High-nitrogen fertilizers such as 27-14-0, 23-23-0, or 24-20-0 at 60 to 80 pounds of N per acre will help correct this condition. It has also been noted that yields of cereals following legumes or grass-legume mixtures are less likely to be lowered.

MAKING GOOD-QUALITY HAY AND SILAGE

The gains in weight or milk production from feeding hay or silage are determined to a large extent by protein and fibre contents and digestibility of feed. Low-quality roughage may be offset by feeding protein supplements and/or grain. Such practices generally are more costly than feeding good-quality roughage. Essential factors in making high-quality hay or silage are as follows:

1. Stage of plant growth. This is the most important single factor controlling forage value. As crops advance from early leaf to seed stages, they gradually drop in feed quality. Most grasses should be cut at the start of flowering, which is around the last week of June or the first week of July. Legumes and grass-legume mixtures should be cut when the legumes begin flowering.

2. Kind of crop. Legumes have higher protein, mineral, and carotene contents than grasses. Legumes do not lose quality as rapidly as grasses at later growth stages.

3. Amount of leaf. The feeding value of leaves is considerably higher than that of stems. Loss of leaf in handling decreases feed value. Leaf losses are likely to occur when legumes are cut and raked for hay.

4. Harvesting losses. Losses of 40 percent to 50 percent in feeding value may result when hay is exposed to rain. Rapid curing and collection of forage reduce these losses.

Table V gives typical nutrient analyses for various hays and illustrates the importance of early harvesting and retention of leaves. Assessment of feed quality can be obtained by sending hay or silage samples to the Feed Testing Laboratory at the University of Saskatchewan. (See also Livestock section, page 152.)

TABLE V

Average Nutrient Levels in Legume, Grass, and Oat Hays
(Dry Matter Basis)

Feed	Protein %	Fibre %	Calcium %	Phosphorous %	Total digestible nutrients %	Carotene mg/lb feed
Alfalfa hay						
Pre-bud stage	19	23	2.1	.30	54	200
Early-bloom stage	17	27	1.2	.23	51	50
Full-bloom stage	15	30	1.3	.20	48	20
Leaves only	24	15	2.4	.29	58	100
Bromegrass hay						
Preheading stage	15	24	0.5	.40	60	100
Pre-flower stage	11	28	0.5	.30	50	50
Full-flower stage	9	32	0.5	.26	49	20
Mature-seed stage	5	32	0.5	.20	47	10
Oat hay						
(soft-dough stage)	9	28	0.2	.19	47	9

Hay Shelters

Protection of hay from the weather is recommended, particularly for hay stored for more than 1 year. Plans for hay shelters are available. (See reference 25.)

Spoiled Sweetclover Hay or Silage Should Not be Fed

If the hay or silage becomes musty or moldy during curing, the blood of animals for which this type of feed is the major roughage is not likely to clot as readily as it normally would. In severe cases the animals may bleed to death. Sweetclover suspected of being moldy should be fed in limited quantities only and not at all for a few weeks before an operation or calving. The use of low-coumarin varieties such as Polara eliminates this problem.

Silage

Preserving forage in the form of silage is gaining in popularity. It offers the following advantages:

1. Field losses of nutrients (leaf shattering and/or weathering) are reduced to a minimum. Top-quality feed can be put up with little regard for the weather; 2. feed reserves can be stored cheaply for many years with little, if any, loss of nutrients; 3. a wider variety of crops can be used for forage, permitting more intensive land use. All cereal grain crops and especially barley make good silage, as do also all grasses and legumes. Corn is the outstanding silage crop because of its high carbohydrate content; 4. hailed, frozen, and weedy crops can be salvaged for feed; 5. the harvesting operation can be highly mechanized, efficient, and economical; 6. silage lends itself to automated feeding.

Silage Making—(Everyone interested in details of silage making should get the bulletin listed as reference 26.)

HAYLAGE

Haylage is low-moisture silage. Its moisture content is about 35 percent to 40 percent. Haylage requires specially designed silos for airtight storage. These may be expensive.

PASTURES AND PASTURE MANAGEMENT

Seeded Pasture

Seeded pastures produce two to three times as much feed as native grass pastures. The seeded grass or grass-legume mixture may provide the sole source of pasture or may be used in combination with native grass pasture.

Carrying Capacity—Differences in soil moisture and soil fertility, and in age and thriftiness of stand result in marked differences in carrying capacity. However, a guide to the carrying capacity of fairly young stands of grass-legume mixtures is approximately as follows (expressed in acres required per cow per month of grazing):

Brown soil zone	0.7-1.5 acres
Dark Brown soil zones	0.5-1.2 acres
Black soil zone	0.4-1.0 acres
Thick Black and Gray-Black soil zone	0.3-0.7 acres
Gray (wooded) soil zone	0.4-1.5 acres

For older stands containing no alfalfa, the acreage required per cow should be approximately doubled.

Management—Very close grazing of seeded pastures should be avoided. Continuous close grazing reduces the total seasonal yield. Seeded pastures should be rested sometime during the pasture season. In the Black and Gray (wooded) soil zones, seeded forage crops should be allowed to grow at least 3 to 4 inches from mid-August to freezeup. This is most important for grass-legume mixtures. An exception is Russian wild rye intended for seed production. Close fall grazing of this grass improves seed yields the following year.

In the moister parts of the province the yield of older stands can be increased with fertilizers. (See Soils and Fertilizers section, page 92.)

Grasses differ in their growth habits and seasonal palatability. Maximum value is secured by grazing different grasses so as to make the best use of their various characteristics. Russian wild ryegrass and crested wheatgrass start growth very early in the spring, so they are particularly useful for spring pasture. Bromegrass begins to grow later in the spring and is productive and palatable throughout the summer. Russian wild ryegrass makes an excellent summer pasture and in the Brown and Dark Brown soil zones it can be used as a late fall and early winter pasture. Its nutrient content remains sufficiently high at this time to provide an adequate level of nutrition for breeding and replacement herds. (See Fig. 5, page 85.)

Rotational grazing has shown no advantage over continuous grazing in Saskatchewan. However, production and animal gains may be increased by seeding separate fields to different grasses and exploiting the growth characteristics of each. Some suggested combinations are:

1. Sufficient acreage of crested wheatgrass-alfalfa or Russian wild ryegrass-alfalfa to carry the stock until mid-June, followed by grazing on native grass. Crested wheatgrass or Russian wild ryegrass should be separated from the native pasture by a fence; 2. in soil zones other than the Brown soil zone, brome-alfalfa or brome-crested wheat-alfalfa mixture pastures may be combined with native grass pastures as in 1. above. Again, the pastures should be separated by fencing; 3. Russian wild rye may be used in a third field for fall and early winter grazing in combination with 1. or 2. above.

Where only a single mixture such as brome-alfalfa, Russian wild ryegrass-alfalfa, or crested wheatgrass-alfalfa is used throughout the grazing season, it is advisable to fence the pasture into two or more fields. In years of high production, grazing can then be confined to certain fields and at least one field can be harvested for hay or silage. Do not graze grass-alfalfa mixtures in the spring until the alfalfa has reached a height of 4 to 6 inches.

Annuals for Pasture—Annual grain crops (fall rye, oats, barley, and wheat) can supplement the perennial grasses during summer and fall. Fall-sown fall rye will provide 7 weeks of productive pasture during May, June, and early July which can be grazed at a heavy stocking rate. Oats seeded on fallow in early spring will, 7 weeks after emergence, provide an additional 7 weeks of grazing. Wheat and barley are not as desirable as oats because of less regrowth potential. Cereal grain stubble fields provide fall pasture.

An acreage in cereals can be an effective management tool, allowing three-way use, as emergency pasture in dry years or when re-establishing perennial forage crop pastures, as a winter fodder source, or as a grain crop.

Bloat—(See Animal Diseases section, page 157.)

Bloat can occur on any feed but is more likely on pastures containing legumes. There is no sure method of prevention, but livestock on alfalfa pastures throughout the year are less likely to bloat than those feeding on alfalfa occasionally. Practices which help prevent bloat are:

1. Use the recommended pasture mixture (see Table II). On dryland pastures, the alfalfa seeding rate must be limited to 1 pound per acre in a mixture; 2. allow livestock to become gradually accustomed to the pasture by turning them into it when they are full; 3. provide some dry hay or straw in the pasture all the time. This may be easily done by swathing a few strips through the pasture prior to grazing; 4. after a grass-legume mixture is cut for hay, the legume recovers much faster than the grass. Thus, caution should be exercised in pasturing, the aftermath of such mixtures or bloat may occur.

Native Grass Pastures

Good native grass pastures provide low-cost grazing. Although relatively low in yield, the grasses composing native pastures are high in feeding value and are liked by grazing animals. Native grass pastures in good condition recover quickly from drought.

Carrying Capacity—The carrying capacity of native grass pastures in good condition varies greatly. To provide feed for the summer, one cow requires from 30 to 35 acres in the drier part of the Brown soil zone, about 15 to 25 acres in the Dark Brown zone, and from 12 to 15 acres in the drier part of the Black soil zone. The carrying capacity may be summarized in terms of acres required per cow per month of grazing as follows:

Brown soil zone	3.0-6.0 acres
Dark Brown soil zone	2.5-4.0 acres
Drier part of Black soil zone	2.0-2.5 acres
Thick Black, Gray-Black and wooded soil zones	1.0-3.0 acres

Where the condition of native grasses is poor, carrying capacity is lower than indicated above and more acres per animal must be provided.

Management—(See references 13, 14, and 15.)

The most important points in managing native pasture concern season of use and rate of grazing. Spring use of native pastures is especially harmful because they grow very slowly at that time, and they should not be grazed before mid-June. Pastures grazed too heavily gradually become unproductive. (See Fig. 6, page 85.)

With overgrazing, good grasses disappear and pasture weeds increase. This trend develops slowly until the weeds are more common than the grasses. An abundance of pasture sage, cactus, broom weed, golden aster, Canada thistle, and many annuals indicates an overgrazed condition. As overgrazing progresses, yields of beef, milk, and other livestock products decrease, soil erosion accelerates, and grasshoppers find the fields to be excellent eggbeds. It must be recognized that, because native grasses have short growing seasons and are low yielders, it is easy to overgraze them. Most small native grass pastures are seriously overgrazed. (For weed control in overgrazed pastures see Weed Control section.)

The proper rates of grazing native grass pasture are given under carrying capacity. Grazing so that some grass is left at the end of the season of an average growth year is a further precaution. From 40 percent to 50 percent of an average season's growth is considered an adequate carry-over. Carry-over is essential to the continuing good health and vigor of native grass pastures. It should be sufficient to trap snow, to produce seed to reseed the pasture, to reduce runoff, and to provide some feed the following spring.

Although mid-May is the earliest that native pastures should be used, their carrying capacity is increased by up to 50 percent when grazing is deferred until mid-June. Cultivated grass-alfalfa mixtures, such as Russian wild ryegrass and alfalfa, or crested wheatgrass and alfalfa, should be used during the grazing period before mid-June.

Proper distribution of stock-watering sites, salt, and shelter ensures better use of pastures. Grasslands more than 1½ miles from watering sites will be undergrazed. Salt licks should be located away from water and occasionally relocated to attract livestock to undergrazed areas.

Bush Pastures (See also reference 18 dealing with brush control)

The northern forest areas are becoming increasingly important for cattle raising and can provide a relatively high yield of nutritious forage. However, the grazing season is short, since the northern grasses and other native pasture plants lose almost all feeding value after the first killing frost. Mineral supplements should be fed during the summer, and mineral and protein supplements must be fed in the fall to obtain good weight gains.

Grasses and other forage plants that grow in bush areas do not stand up well under heavy use. If too heavily grazed, the forage plants will be replaced by weeds that cattle do not eat. Bush pastures, like native grass pastures, should not be grazed before mid-May.

The carrying capacity of a particular bush pasture will depend on the area and kind of bush in relation to the areas of open grassland and meadow. Open bush areas could carry one cow on 10 acres or less in a 4-month season but, if the bush is dense, up to 30 acres per cow are required.

Dry meadows in a bush pasture are the favorite grazing place of cattle and must be carefully managed to prevent overgrazing. If they are in good condition, they will carry up to one cow per acre for the grazing season. Open grassland is less productive, but will usually carry one cow on from 5 to 15 acres.

Under certain circumstances, brush suppression, using herbicides, may be useful. (See Weed Control section, page 74.) However, if brush control is necessary because of brush invasion, there should be an appraisal of the other factors of pasture management.

Bush areas with good or reasonably good soils should be broken and seeded to improved grasses and legumes. Such development is expensive but has proven profitable. Seeded pastures in the bush area are now being stocked at rates of 1 to 2.5 acres per cow per season. On poorer soils, the number of acres per cow may have to be doubled.

SEED PRODUCTION

Weeds

Fields intended to produce seed should be free of noxious weeds. For grass seed production they should be completely free of couch grass. Mechanical separation of couch grass seed from seed of other large seeded grasses, and of volunteer legumes from seed of a specific legume is difficult or impossible.

Classes of Seed (See reference 32)

Seed of high quality should be used in all seed-production enterprises. The three classes of pedigreed forage seeds are: Breeder, Foundation, and Certified. A fourth class, Registered, has been dropped for Canadian seed but may still be obtained for varieties produced in other countries. Breeder seed is grown by plant-breeding institutions and used to produce Foundation seed. Foundation produces Certified. Certified seed is the class which commercial seed growers should attempt to produce. Foundation and Registered classes have higher isolation and purity requirements than the Certified class.

For most Canadian varieties, Foundation seed is distributed in Saskatchewan through the Saskatchewan Department of Agriculture, Regina, and by Canadian Seed Trade Association companies which are also members of the Seed Multiplication Division.

Foundation seed of varieties originating in other countries can best be obtained through the Canadian Seed Growers' Association, Ottawa, or seed companies. Regulations governing pedigreed seed production can be obtained from the Saskatchewan Branch, Canadian Seed Growers' Association, c/o Saskatchewan Department of Agriculture, Regina, or from the Canadian Seed Growers' Association, Ottawa.

Contract Production of Non-Licensed Varieties

Foreign crop varieties which are not licensed for sale in Canada may still be grown for seed under contract arrangements. However, all seed of these varieties must be shipped out of Canada. When grown in Canada they come under the same crop and seed inspection regulations as Canadian varieties. Further information on contract production may be obtained from the Canadian Seed Growers' Association, Ottawa, or the Plant Products Division, Canada Department of Agriculture, Saskatoon.

Management of Seed Crops

Most grasses have yielded highest when grown in rows 3 feet apart, especially in the Brown and Dark Brown soil zones. On the Black soils, good seed crops can be obtained from closer spacings. The use of a companion crop may seriously reduce the seed yields of grasses the year after seeding. Where rapid establishment is wanted, the companion crop should be omitted and weeds controlled with herbicides. (See Weed Control section.) Applications of nitrogen fertilizers often benefit grass seed production. (See Soils and Fertilizers section.)

When To Harvest Seed

Most grasses shatter their seeds readily as the seeds approach maturity. Seeds may be mature and shattering even though the leaves are still green. Strong winds at this stage will cause serious losses of seed. As grass crops approach maturity they should be examined daily for evidence of shattering. If some shattering occurs when a few heads are struck lightly across the palm of the hand, cutting should begin.

Harvesting and Threshing Seed

Straight combining of forage crops is generally not recommended but it may be used on crops that do not shatter readily. If a crop must be straight-combined, the seed should be dried before storing.

The best method is to swath the crop and thresh with a rub-bar cylinder combine. For grass crops, the cylinder and concaves should be set fairly wide apart. For legume crops, the concaves should be set up close. With all types of combines and threshing machines, the cylinder speed should be reduced for grass crops and increased for legume crops. The wind blast should be reduced for grasses but this may not be necessary for legumes. The adjustable sieve should be set in a relatively flat position and the back board lowered sufficiently to allow the straw to pass over it. This prevents too much broken straw from going into the return.

Seed Cleaning (See reference 27)

Seed of grasses and legumes can be cleaned successfully on the farm with a fanning mill, provided the proper selection of sieves is made. Companies selling cleaning machinery can provide information on the selection of sieves for forage crops. The seed should be run over the mill at least twice. In the first operation, the coarse straws and unbroken spikelets or pods are removed; in the second, the weed seeds and finer inert material can be cleaned out. Commercial seed-cleaning facilities are available at several points in the province.

Seed Production of Grasses

Seed production of bromegrass, crested wheatgrass, Russian wild ryegrass, and creeping red fescue is dealt with in separate bulletins, and the reader is referred to references 1, 2, 3, 4, and 5. For threshing slender wheatgrass and intermediate wheat, methods used for crested wheatgrass can be followed.

Shattering is a considerable danger and it is advisable to cut with a swather before the seed is brittle, and thresh about a week later.

Timothy—Climax, Bounty, and Champ may be grown successfully for seed in the more moist areas of Northern Saskatchewan. It appears impractical to attempt seed production in the Brown, Dark Brown, and drier parts of the Black soil zones. Seeding should be at a rate of 2 to 3 pounds per acre in 6-inch drills and 4 pounds per acre when broadcast. The crop generally is swathed and picked up, as shattering losses are high for straight combining. Cylinder speed and concave settings should be adjusted to give a minimum of dehulled seed. Seed without hulls rapidly loses germination capacity and is downgraded.

Seed Production of Legumes

Alfalfa, alsike clover, sweetclover, and red clover must be cross-pollinated to produce satisfactory yields of seed. These crops are pollinated by bees—bumblebees, leaf-cutter bees, and honeybees. Because each type of bee prefers certain kinds of bloom, it is important to consider the problem of pollination when deciding what crop to grow.

Honeybees are good pollinators of sweetclover, alsike clover, sainfoin, and birdsfoot trefoil. They are also good pollinators of red clover, not because the bees prefer to work it, but because it is a rich nectar and pollen source later in the season. One strong colony will provide enough pollinators for 1 acre of sweetclover or red clover, or 2 acres of alsike. More colonies per acre may result in increased seed yield, but honey production per colony will be reduced.

Honeybees tend to disperse and collect food from the most plentiful and attractive bloom within their flight range. For maximum benefit, the hives should be placed within or alongside the crop.

Alfalfa presents difficult pollination problems. Honeybees contribute very little to seed setting of alfalfa. Only a few species of bumblebees and leaf-cutter bees are valuable pollinators.

Fields should be located to make the best use of available pollinators. Fields should be small, not larger than 25 acres, long and narrow, and situated next to or even surrounded by unbroken native land. This may not ensure good yields, because the right pollinators may not be present, and wild bee populations vary greatly from year to year. Often a part of the field can be cut out for hay so that the bee activity will be concentrated on the remainder. If alfalfa pods are not forming by late July, the field should be cut for hay.

Alfalfa seed growers should consider using the alfalfa leaf-cutter bee **Megachile rotundata.** These bees are reared in tunnels in wood or polystyrene. When they and their nests are placed in an alfalfa field, most of them will stay there and pollinate it. The amount of seed produced depends on many factors, including climate, number of bees per acre, and the general growth and vigor of the alfalfa stand. Compared with the southern part of the province, the northern areas usually have a shorter, cooler pollination period and thus may require more bees per acre to produce satisfactory seed yields. For further information concerning this bee, consult the Canada Agriculture Research Stations at Melfort, Saskatoon, or Swift Current. (See references 8 and 9 for more information.)

Sulfur-bearing fertilizers often are necessary in the Gray soil zone, especially on sandy and sandy loam soils. (See General Management of Grasses and Legumes—Soils and Fertilizer section, page 93.)

Insect pests, particularly plant bugs, cause severe bud-blasting and flower-fall in alfalfa seed fields. Early spring burning of the alfalfa stubble and trash will control certain injurious insects, and will also assist in the control of the fungi that cause leaf and stem diseases. If weeds such as Russian pigweed, yellow mustard, or dragon head are present, spray early in the spring, before alfalfa has made much growth, with an appropriate herbicide. (See Weed Control section, page 74.)

Alfalfa is ready to harvest from early September onward. It may be cut with a swather and threshed with a combine. The swath should be packed or rolled so it will not be windblown. Straight combining is a general practice also, but it is usually necessary to leave the crop until frost has destroyed all or most of the green growth. Defoliants may be used to dry up the foliage and aid harvesting rather than waiting for a sharp frost.

Sweetclover should be cut when about two-thirds of the pods have ripened, which is usually from mid-August to early September. It shatters readily and should be cut with a swather, preferably on a dull day or after a very light dew, but it should not be straight-combined. The concave adjustment should be such as to leave the pods on most of the seeds, since weed seeds can then be more readily removed. The pods are removed in scarifying the seed.

Sweetclover is very susceptible to 2,4-D damage at the flowering stage. Damage may even be caused when a poorly cleaned weed sprayer is used later to apply an insecticide to sweetclover. Wind drift can carry 2,4-D from an adjacent grain field and cause drastic seed losses.

For up-to-date information on the control of the sweetclover weevil, see Insect Pests of Plants and Livestock Section.

Red clover should be grown on land well-favored with moisture but with good drainage. It is usually ready to harvest about the middle of August or when the heads are dark brown or black. Straight combining may result in loss of seed through overripe heads tending to break off. A better method is to use a mower with a windrowing attachment or a swather followed by a pickup combine. To get good separation of the seed the crop must be dry, the concaves set close, a high cylinder speed maintained, and the cylinder not overloaded.

Alsike clover is a heavy seed producer but must be grown in favored locations. Rather poorly drained soils and locations where water will collect for 1 or 2 weeks in the spring are preferred. The crop usually is mature early in August. Because it shatters very easily, alsike should not be left for straight combining. The best method is to use a mower with a bunching attachment, preferably when the crop is tough after dew or rain. The bunches may be picked up and threshed with a combine or threshing machine. A swather followed by a pickup combine may be successful in good stands. Alsike threshes easily if the crop is dry and the machine is not overloaded. Handling the crop before threshing should be avoided whenever possible because of losses from shattering.

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GRAIN CROPS

Saskatchewan continues to be the leading producer of cereal and oilseed crops in Canada. Approximately 24.5 million acres are sown to these crops each year. In 1971, estimates indicate that this province produced 67 percent of Canada's wheat, 44 percent of barley, 29 percent of oats, 47 percent of rye, 51 percent of flax, and 52 percent of rapeseed. The relative importance of the major grain and oilseed crops in Saskatchewan in 1971 is shown in Table I.

TABLE I

Acreages and Production from Cereal and Oilseed Crops in Saskatchewan in 1971*

Crop	Acreage	Yield (cwt per acre)	Production (tons)
Spring Wheat	10,800,000	16.6	8,942,400
Durum Wheat	2,000,000	14.7	1,470,000
Oats for Grain	1,960,000	19.2	1,885,520
Barley	6,300,000	21.7	6,835,500
Fall Rye	550,000	11.9	326,425
Spring Rye	70,000	9.6	33,530
Flax	1,030,000	7.8	400,670
Rapeseed	2,750,000	9.3	1,285,625
Mustard	175,000	9.5	83,125
Sunflower	65,000	5.1	21,125

*Statistics Canada, November, 1971

Uncertain market conditions caused a decline in wheat production in the province over recent years and an upsurge in interest in other crops. The most spectacular increase has been in rapeseed acreage, a five-fold increase since 1968. Rapeseed is now the major oilseed crop grown in Saskatchewan. Barley and, to a lesser extent, flax also showed marked increases in importance in 1971. Larger acreages of minor crops such as sunflowers and peas are being sown, indicating the decreasing dependency on wheat as the major crop and a trend to greater diversity in crop production throughout the province.

CROP-PRODUCTION AREAS OF SASKATCHEWAN

The arable region of Saskatchewan can be divided into three broad crop-production areas on the basis of major soil zones and climatic regions. These areas are each subject to one or more of the major hazards to grain production in the province.

The three crop-production areas are shown in Fig. 1. This map also shows the general distribution of the major hazards, frost, drought, and rusts. The change from one area to another is gradual and the importance of a crop hazard and its distribution within an area will vary considerably from year to year.

Area 1. (Brown and Dark Brown Soil Zone)
Drought is a definite hazard in this area, especially in the southwestern region, and winds of high velocity are common. Wheat stem sawfly is most likely to be serious in the southwest. Rust is usually confined to the southeastern region. Frost is rarely a hazard except in localized areas.

Area 2. (Black Soil Zone)
Drought is less likely to be a limiting factor in this area and the frost-free period is fairly long. Rust frequently occurs in the eastern regions of this area.

Area 3. (Gray Soil Zone)
Rainfall is usually adequate for crop production but frost and wet harvest weather can be definite hazards. Rust is seldom a problem. Early maturity is an important consideration when choosing crop varieties for this area.

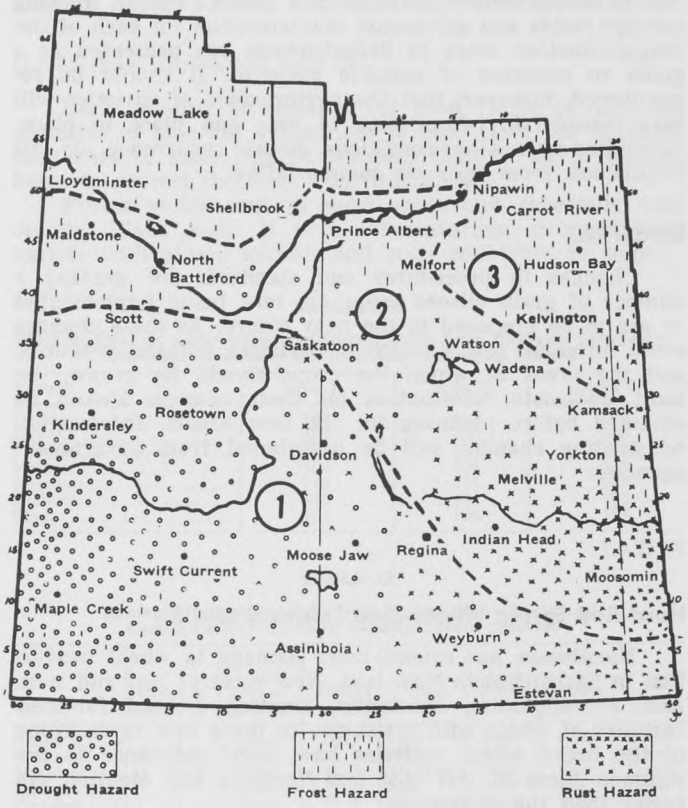


Fig. 1—Crop production areas and distribution of major hazards to grain production in Saskatchewan

Other serious problems encountered in crop production include damage from hailstorms and localized outbreaks of destructive insects and diseases, especially on rapeseed. While these other hazards tend to be associated with general areas in the province, their locations vary considerably.

For detailed information on cultural practices and crop diseases and insect pests occurring in Saskatchewan, see Cropping Practices section, page 129, Plant Diseases section, page 115, and Insect Pests section, page 100.

VARIETIES

Improved crop varieties are being developed continually. While increased yield is a major objective, plant breeders are concerned with other important agronomic characteristics, such as maturity, resistance to drought and lodging and resistance to diseases and insect pests, as well as maintaining desirable quality attributes. Greater emphasis is being placed on developing varieties to meet specific market requirements, a recent example being low erucic acid rapeseed varieties. The potential of new crops for Saskatchewan is also being investigated.

All varieties with potential value for Saskatchewan are tested extensively throughout the province by the research stations of the Canada Department of Agriculture and by the University of Saskatchewan. Varieties are licensed only

after full consideration of their quality, yielding ability, and agronomic characteristics. This ensures their suitability both for domestic and export markets.

Since varieties change rapidly, readers should consult the pamphlet "Varieties of Grain Crops for Saskatchewan" for up-to-date variety recommendations. A revised pamphlet is available early in January each year and may be obtained from agricultural representatives, research stations, the University of Saskatchewan, Saskatoon, grain companies, etc.

In what follows, the main characteristics of the currently recommended varieties are given. Tables showing average yields and agronomic characteristics for each of the crop-production areas in Saskatchewan are presented as a guide to selection of suitable varieties. It should be remembered, however, that the performance of varieties will vary considerably from year to year and place to place, depending on weather conditions, disease occurrence, etc. All results are from tests on summerfallow.

GRADING

Changes in procedures and standards for grading a number of grain oilseed crops are now being implemented or are to be proposed in the near future. As these changes could influence the selection of varieties, cultural practices, and the areas in which the crops should be grown, the most up-to-date information on these changes should be obtained before planning for the new season. Information on grading changes will be distributed from government agencies.

WHEAT

Hard Red Spring Wheat (See Tables II and III)

No disease has caused more damage to wheat production in Saskatchewan than rust. New races of leaf and stem rust are appearing constantly, creating a need for new varieties of wheat with resistance to these new races. None of the bread wheat varieties have good resistance to the common races of leaf rust but Neepawa and Manitou are better than the others.

TABLE II

Yields of Wheat as a Percentage of Manitou. Data from Co-operative Tests and Cereal Variety Trials in Saskatchewan, 1964-1971

Variety	Area 1	Area 2	Area 3
Bread types			
Canthatch	95	96	97
Chinook	93	88	—
Cypress	90	86	85
Manitou	100	100	100
Neepawa	104	101	102
Selkirk	91	94	96
Thatcher	100	98	98
Feed type			
Pitic 62*	118	118	119

*Data for 4 years

TABLE III

Agronomic Data for Wheat from Co-operative Tests and Cereal Variety Trials, 1964-1971

Variety	Order of maturity	Bushel weight	Resistance to			
			Lodging	Stem rust	Leaf rust	Loose smut
Bread types						
Canthatch	1	63.8	Good	Fair	Poor	Fair
Chinook	2	65.2	Fair	Poor	Poor	Poor
Cypress	2	65.2	Fair	Poor	Poor	Poor
Manitou	2	64.8	Good	Good	Fair	Fair
Neepawa	1	65.1	Good	Good	Fair	Fair
Selkirk	1	63.6	Good	Good	Fair	Good
Thatcher	2	64.8	Good	Poor	Poor	Fair
Feed						
Pitic 62*	5	62.0	Good	Poor	Poor	Poor

*Data for 4 years

Selkirk, licensed in 1953, ripens slightly earlier than Thatcher and has a larger, less attractive kernel. It has strong straw and is resistant to race 15B stem rust, the most common race at present. Selkirk shatters easily and should be swathed promptly when mature.

Canthatch, licensed in 1959, is similar to Thatcher in all respects except that it has resistance to race 15B stem rust.

Manitou, released in 1965 as a replacement for Selkirk, is a Thatcher type also but has good resistance to the common races of stem rust. It has strong straw, matures 1 to 2 days later than Thatcher, and is one of the main varieties grown in Saskatchewan.

Neepawa, a variety of the Thatcher type licensed in 1969, has good resistance to the common races of stem rust. It has strong straw and is slightly earlier maturing than Manitou. Neepawa is slightly higher yielding than Manitou and is rapidly gaining popularity.

Cypress and **Chinook** have solid stems and should be used where wheat-stem sawflies cause damage. Sawfly-resistant wheats lodge and shatter more easily than Manitou or Neepawa and are more likely to be damaged by late spring frost and hot, dry weather. These varieties are not resistant to the common races of leaf and stem rust. Cypress is more resistant to sawflies than Chinook.

Durum Wheats (See Tables IV and V)

Ramsey and **Stewart 63** are rust-resistant varieties which ripen about a week later than the bread wheats and have taller, weaker straw.

Hercules, licensed in 1969, is approximately 1 week earlier maturing and 9 inches shorter than Stewart 63. Hercules has good resistance to lodging, stem and leaf rust, and loose smut. It also has moderate resistance to kernel smudge. The quality of Hercules is a distinct improvement over the older varieties. Hercules is the only durum variety considered early enough to be grown in Area 3.

TABLE IV

Yields of Durum Wheat as a Percentage of Stewart 63. Data from Co-operative Tests and Cereal Variety Trials in Saskatchewan 1964-1971

Variety	Area 1	Area 2
Pelissier	104	95
Ramsey	99	97
Stewart 63	100	100
Hercules	92	92
Wascana	113	106

TABLE V

Agronomic Data from Co-operative Durum Wheat Tests, 1967-1970

Variety	Order of maturity	Bushel weight	Resistance to			
			Lodging	Stem rust	Leaf rust	Loose smut
Hercules	1	65.6	Good	Good	Good	Good
Pelissier	4	64.1	Fair	Poor	Good	Good
Stewart 63	3	65.8	Fair	Good	Good	Fair
Wascana	2	63.9	Good	Good	Good	Good

Wascana, licensed in 1971, is similar in quality to Hercules. It is 2 to 3 days later maturing and about 2 inches taller than Hercules. Wascana is resistant to loose smut, leaf and stem rust, and moderately resistant to kernel smudge. Wascana has outyielded the other varieties and does particularly well in the Brown soil zone.

Pelissier is a popular variety in drier areas because of its drought resistance.

Other Classes of Wheats

The Task Force on Agriculture predicted a demand, by 1980, for 240 million bushels of wheat of grades other than Canada's traditional Hard Red Spring Wheat; 80 million bushels of feed wheat and 160 million bushels of wheat with quality lower than Marquis. This lower quality wheat

is called Fair Average Quality (FAQ) wheat. As part of their research, plant breeders have been breeding for high yield with less regard for quality. Varieties with lower bread-making quality than Marquis but higher yield may be available to growers in Saskatchewan in the near future. Breeders are also producing better feed wheats than Pitic 62.

Pitic 62, a Mexican variety, is high yielding but is susceptible to some races of rust, is too late maturing for general use, and has low bushel weight.

Soft White Spring Wheats should be grown only on irrigated land and under contract with a milling company. **Lemhi 62,** the only variety of acceptable quality, is susceptible to leaf rust.

Winter Wheats—Hard red winter wheat is grown in Saskatchewan with very limited success because of winter killing. **Sundance,** licensed in 1971, is considered an alternative to either **Kharkov** or **Winalta.** It is higher yielding but does not possess any greater winterhardiness than Winalta.

Soft white winter wheat (Gaines) will rarely survive the winter in Saskatchewan.

BARLEY (See Tables VI and VII)

Barley is the most responsive of the small grain crops to good management. Early seeding on clean land having high fertility is required for optimum production. There are three main uses for barley: 1. Feed; 2. malting; 3. pearling. Barley also makes an excellent silage crop. (See Forage Crops section, page 58, for more information on silage.)

TABLE VI

Yields of Barley as a Percentage of Conquest. Data from Co-operative Tests and Cereal Variety Trials in Saskatchewan, 1968-71

Variety	Type	Area 1	Area 2	Area 3
Eligible for CW Grades				
Bonanza	6-row	112	112	110
Conquest	6-row	100	100	100
Paragon	6-row	109	106	103
Betzes	2-row	111	104	105
Fergus	2-row	115	109	111
Centennial	2-row	118	108	106
Feed				
Galt	6-row	115	109	104

TABLE VII

Agronomic Data for Barley from Co-operative Tests and Cereal Variety Trials in Saskatchewan, 1969-71

Variety	Order of maturity	Bushel weight	Resistance to				
			Lodging	Stem rust	Loose smut	Covered smut	Root rot
Eligible for CW Grades							
Bonanza	2	51.3	Good	Good	Good	Fair	Good
Conquest	1	50.7	Good	Good	Good	Fair	Good
Paragon	4	52.0	Good	Good	Good	Fair	Good
Betzes	3	53.7	Fair	Poor	Poor	Poor	Good
Fergus	4	55.1	Fair	Poor	Fair	Fair	Good
Centennial	5	52.4	Good	Poor	Poor	Poor	Fair
Feed							
Galt	4	50.5	Good	Good	Poor	Poor	Poor

Six-Row Varieties

Bonanza, Conquest, and **Paragon** are eligible for the highest CW (Canada-Western) grades and all possess good resistance to both stem rust and loose smut. Paragon is a smooth-awned variety that is higher yielding than Conquest, has shorter straw but is 3 to 5 days later maturing. However, the malting quality of Paragon is generally least acceptable to the maltsters. Bonanza is a smooth-awned malting variety which outyields Paragon and is intermediate between Paragon and Conquest in maturity and height.

Galt is a high-yielding feed variety. It is short-strawed, semi-smooth awned and is the only six-row variety with good resistance to both lodging and shattering.

Two-Row Varieties

Betzes, Fergus, and **Centennial** are eligible for CW grades. Betzes is a rough-awned variety eligible for the highest two-row grade. Because of good quality and light color of seed it is very popular for pearling. Centennial has the best resistance to lodging but is the latest maturing variety. Fergus is a rough-awned variety that yields well throughout the area. In Western Canada, however, it is rarely purchased for malting.

Compana and **Palliser** are not eligible for CW grades and are locally adapted to Southwestern Saskatchewan.

OATS (See Tables VIII and IX)

Early seeding is essential for good yields of oats. All varieties of oats are susceptible to race C.10, the predominant race of stem rust in Western Canada. Early seeding helps to protect the crop from this disease.

Fraser yields well in most areas and especially well on the Black soils. It is a late-maturing, strong-strawed variety with plump kernels and good resistance to smut.

TABLE VIII

Yield of Oats as a Percentage of Garry. Data from Co-operative Tests and Cereal Variety Trials in Saskatchewan, 1968-71

Variety	Area 1	Area 2	Area 3
Fraser	105	111	108
Garry	100	100	100
Harmon	102	103	104
Kelsey	104	106	111
Random	114	111	115
Rodney	102	104	103
Sioux	104	106	107

TABLE IX

Agronomic Data for Oats from Co-operative Tests and Cereal Variety Trials in Saskatchewan, 1968-1971

Variety	Order of maturity	Resistance to lodging	Bushel weight	Hull %	Resistance to		
					Stem rust	Crown rust	Smut
Fraser	4	Good	40.9	Low	Poor	Poor	Good
Garry	2	Good	40.3	High	Poor	Fair	Good
Harmon	3	Good	40.3	Medium	Poor	Fair	Good
Kelsey	2	Good	39.8	Low	Poor	Fair	Good
Random	2	Good	38.6	Medium	Poor	Fair	Poor
Rodney	3	Good	41.0	Low	Poor	Fair	Good
Sioux	1	Good	41.0	Medium	Poor	Poor	Good

Rodney is a plump-seeded variety that yields less and matures 2 to 3 days earlier than Fraser. It is resistant to smut and fairly resistant to leaf rust. The kernels have thin hulls and peel easily.

Harmon is similar to Rodney in yield, maturity, straw strength, and kernel size. It is fairly resistant to leaf rust and the kernels have less tendency to peel.

Garry is a strong-strawed variety and performs reasonably well over a wide range of soils. It matures early and has fair resistance to leaf rust.

Kelsey is a slender, strong-strawed variety and is well adapted to all areas. The kernels have very low hull content and are high in energy. Kelsey matures as early as Garry.

Sioux is well adapted to the drier areas. It matures early and has good resistance to smut. Sioux and Kelsey have slender straw which may be important in livestock feeding.

Random, licensed in 1971, yields well in most areas but performs best on the Black soils. Random has short, strong straw and matures slightly later than Garry. It is susceptible to stem rust and smut.

Torch and **Vicar** are medium maturing, hulless varieties. They are resistant to smut but susceptible to stem rust.

RYE (See Table X)

There are two types of rye: An annual type that is sown in the spring; and a winter-annual type that must be

sown in the fall in order to produce grain. Fall or winter rye is grown much more extensively than spring rye because it provides more protection against soil erosion, better weed control, and its harvest does not conflict with that of wheat. Although winter killing is a hazard with fall rye, the danger is slight if the most winter-hardy varieties are sown at the proper time. The objective is to have the plants well established by freezeup. This usually means seeding sometime during the last week in August or the first week in September, depending upon local conditions.

TABLE X

Yields, as a Percentage of Antelope, and Agronomic Data for Fall Rye. Data from Co-operative Tests, 1966-70

Variety	Yield*		Resistance to			Height inches
	Area 1	Area 2	Winter-killing	Lodging	Shatter-ing	
Antelope	100	100	Good	Poor	Poor	42
Cougar	126	117	Fair	Good	Good	37
Frontier	108	123	Good	Poor	Fair	42
Kodiak	108	113	Fair	Fair	Fair	43

*Failure to show yield data for Area 3 is due to a lack of test sites. Fall rye is grown successfully in this area of Saskatchewan.

TABLE XI

Yield, as a Percentage of Redwood 65, and Agronomic Data for Flax. Data from Variety Trials in Saskatchewan, 1969-71

Variety	Yield			Order of maturity	Resistance to		Oil quality	Seed size
	Area 1	Area 2	Area 3		Rust	Wilt		
Noralta	95	99	96	1	Good	Good	Good	Small
Norland	98	101	92	2	Good	Fair	Good	Large
Redwood 65	100	100	100	2	Good	Good	Good	Medium

Fall Rye

Antelope, Cougar, and **Frontier** are the most commonly grown varieties. Although Cougar is not as winter-hardy as the other two varieties, it is popular because of its shorter straw and resistance to shattering.

Kodiak, licensed in 1971, is a selection from Sangaste with the characteristic large kernels but not so excessively tall. It is more winter-hardy than Sangaste, about equal to Cougar.

Petkus and **Dominant** rarely survive the winter in Saskatchewan.

Spring Rye

Prolific is the only commercial variety grown in Saskatchewan.

RAPESEED (See Table XII)

Rapeseed is best adapted to the Parkland area of the province. Varieties of the **Brassica (B) napus** species (Argentine type) are higher yielding than varieties of the **B. campestris** species (Turnip rape) under the more favorable moisture conditions of the northcentral part of the province. In areas where frost or drought may occur, varieties of the earlier maturing **B. campestris** species generally give more reliable results. During the last 4-year period in Western Canada, **B. napus** yielded approximately 20 to 25 percent more seed per acre than **B. campestris. B. campestris** is more resistant to frost in the seedling stage and less susceptible to seed shattering at maturity. However, it is more susceptible to disease than **B. napus,** which is resistant to the white rust-downy mildew (staghead) disease.

To minimize the possibility of insect and disease problems, rapeseed should not be sown on rapeseed stubble. Growers should examine fields frequently and be prepared to apply insect-control measures promptly.

B. napus—The varieties **Oro** and **Zephyr** produce a seed oil containing a low level of erucic acid. Zephyr is higher yielding and matures about 1 day earlier than Oro.

TABLE XII

Yield, as a Percentage of Echo, and Agronomic Data for Rapeseed. Data from Co-operative Tests in Saskatchewan, 1968-71

Variety	Area 2			Area 3			Height inches
	Yield	Maturity in days	% Oil	Yield	Maturity in days	% Oil	
Brassica napus (Argentine type)							
Target	116	99	43.4	117	105	44.5	37
Turret	115	99	44.3	107	106	44.5	36
Oro	106	102	40.6	103	108	41.3	42
Zephyr	109	100	40.9	113	106	41.1	41
Brassica campestris (Turnip type)							
Echo	100	88	41.7	100	89	41.1	35
Polar	96	88	42.9	92	89	42.6	35
Span*	94	88	40.8	90	88	39.9	34

*Data for 2 years

Target and **Turret** are the best adapted normal erucic acid varieties.

B. campestris—Span is the only licensed variety producing a low erucic acid oil.

Echo continues to produce the highest seed yield while **Polar** produces seed with the highest oil content.

It is expected that the changeover to low erucic acid rapeseed (LEAR) varieties will occur very rapidly as the domestic refiners begin to exclusively use this new type of oil. The export market is also expected to request this type of seed as soon as continuity of supply is assured. Development of improved strains of the LEAR type has been given high priority and as a result a rapid change and improvement in varieties can be expected in the near future.

FLAX (See Table XI)

Many of the flax diseases, including rust, live over winter on the straw. For this reason flax should not be grown on flax stubble. All varieties are susceptible to pasmo and aster yellows. To control seed-borne diseases, seed flax should be treated with a fungicide at the rate and time recommended by the manufacturer of the particular fungicide used.

All the flax varieties described below are resistant to rust and wilt. They can be divided into two groups on the basis of maturity.

Redwood 65 and **Norland** are late-maturing varieties that do well throughout the province. Redwood 65 is an improved Redwood. Norland is the only white-flowered variety.

Noralta is an early-maturing variety which should be used when seeding is delayed or in northern areas where frost is a hazard. Noralta has yielded nearly as well as Redwood 65.

Frozen flax should be analyzed to determine that it is free from prussic acid before using it for livestock feed.

MINOR CROPS

Sunflower

Sunflowers can be grown in Central and Southern Saskatchewan by using early varieties like **Krasnodarets and Armavirec.** These varieties require about 120 days to escape frost injury. Early planting is recommended since sunflower seedlings can tolerate some frost.

Sunflowers should be planted on clean summerfallow. Seeding rates vary from 4 to 8 pounds per acre, depending on seed size, available moisture, and soil fertility. Rows can be 6 inches to 18 inches apart, depending on available equipment. Approximately 30,000 plants per acre are sufficient for areas with good moisture and soil fertility. This should be reduced to about half that number for the drier areas. Chemical weed control is available; however reasonable weed control can be obtained by timely cross harrowing during the earlier stages of growth. Sunflowers are very sensitive to 2,4-D drift. Special attachments are required for combine harvesting.

Safflower

Safflower is a higher risk crop than sunflowers and requires 120 to 140 days to mature. It can tolerate some frost in the early seedling stage but is easily damaged by fall frosts. Clean land is required because it is a poor weed competitor in its early stages of growth. Dry atmospheric conditions are required during flowering for maximum seed set; otherwise many empty hulls are produced which lower both yield and oil content. Seed yields are extremely variable. Safflower can be planted and harvested with conventional grain equipment. Its most suitable area of production is the southern and southwestern part of the province.

Mustard

Three types of mustard, Brown, Oriental, and Yellow, are grown commercially in Saskatchewan. All show good adaptation to the Brown and Dark Brown soil zones. Mustard is usually grown under contract.

Brown (reddish-brown seeded) and **Oriental** (90 percent yellow and 10 percent brown seeded) mustard are equal to **Brassica napus** (Argentine rape) in seed size, height, and shattering resistance. They yield slightly more than Echo rapeseed and are intermediate between Echo rapeseed and wheat in drought tolerance and maturity.

Yellow (yellow seeded) mustard is equal to **B. campestris** (Turnip rape) varieties in maturity and height, and is superior in shattering resistance. Yield is generally lower than Echo rapeseed. Seed size is larger than rapeseed and the other mustards.

Mixtures of mustard and rapeseed always result in reduced economic returns. To maintain high-quality seed of either mustard or rapeseed, these crops should not be grown on the same farm and probably not in the same district.

Buckwheat

Buckwheat will grow under a wide range of soil conditions; well drained, sandy loams are preferable. It is not usually included in a regular rotation because other crops are more profitable. However, it can be grown to advantage when spring conditions delay seeding. It should be grown on clean land because volunteer grain is difficult to separate from buckwheat.

Buckwheat is very susceptible to frost at all stages of growth. Early-June seeding is recommended. It is also very sensitive to high temperatures and dry weather especially at blooming time. It does not recover from lodging as do most other crops. Maturity is very uneven. Buckwheat is swathed when the maximum number of seeds are ripe or when there is a danger of frost. Shattering can also be a problem. Yields in Saskatchewan have been extremely variable.

Buckwheat markets are limited, so contract production is advised.

Canary Seed

This is an annual with the same maturity requirement as wheat. The seed is about the size of flax and should not be sown deeply. Hot, dry weather at heading time can reduce yields to very low levels. Herbicides can be used for the control of broadleaved weeds.

Seed and detailed information are available from contract buyers of the crop.

Triticale

Triticale is a new man-made species derived from wheat and rye. **Rosner** is the only variety licensed in Canada thus far. It is lower yielding than other cereals on the Prairies but improved varieties are expected which will make Triticale more competitive.

Peas

Field peas do well in the moist areas of the province. Growers should investigate marketing prospects before planting this crop. The variety **Century** is preferred for the food trade. Both **Century** and **Trapper** are suitable for livestock feed.

Field peas grown from properly inoculated seed normally contain about 24 percent protein and have been shown to be a useful ingredient for swine, poultry, and cattle rations. Protein content has been found to vary considerably between fields of the same variety. Therefore it is advisable to obtain a protein analysis on peas that are used in livestock rations.

Lentils

Lentils are an annual legume crop grown for human food. They have about the same growing season requirements as wheat. The main production problems are weed control and short growth; the latter makes harvesting difficult. To assure a market, it is advisable to grow lentils under contract.

Horse Beans

Horse beans are grown for livestock feeding and for human food. They are adapted to cool, moist areas and should be planted early. They are susceptible to 2,4-D type herbicides. Horse beans should be grown under contract.

Field Beans

Field beans are frost sensitive. Early-maturing varieties should be grown, and planting should be delayed until after danger of spring frost. Market opportunities are limited and only small areas should be grown on an experimental basis.

Corn

Corn is recommended for silage purposes only, since grain corn does not usually mature in Saskatchewan.

SEED FACTS

High-quality seed of a variety suited to the area in which it is to be grown is basic to good crop production. Seed quality is based on purity of variety, germination, and freedom from other crop seeds, weed seeds, and diseases. All seed which is advertised or sold must conform to the standards of the Canada Seeds Act. Pedigreed seed meets higher standards than the minima for commercial seed. A good farm practice is to use Certified seed regularly and especially whenever a different variety is adopted. Certified seed of wheat, barley, oats, rye, and flax may be available in bulk as well as in sealed bags. For a number of years farmers have been allowed to deliver commercial grain above the Canadian wheat board quota to pay for pedigreed seed.

Non-pedigreed seed should be tested for germination. This is especially important if the grain was frozen or harvested with a high moisture content. Some grain elevator companies provide free germination tests. Germination tests may also be obtained from the Plant Products Division, Canada Department of Agriculture, 1420 Avord Tower, Saskatoon. Samples for germination tests should represent the cleaned grain which will be sown.

SEED CLEANING

Commercial grain to be used for seed should be carefully cleaned and graded to remove weed seeds, inert matter, and small or imperfect kernels. Many farmers have

their seed cleaned at a country elevator. Often the operator is rushed for time and is urged not to clean out too much of the small seed. This is false economy. Since country elevators service a wide area and a number of crops, seed may be contaminated with weed and other crop seeds which were not in the grain when it was brought in for cleaning.

SEED TREATMENT

See Plant Diseases and Insect Pests sections.

DAMP AND FROZEN SEED

Seed which is stored damp or tough may be low in germination. Grain which is being saved for seed should be dried if necessary, soon after harvest. Drying temperature should be kept below 100°F for batch driers, or 110°F for recirculating and continuous driers. Frozen grain should never be sown without a laboratory germination test. There is frequently a high percentage of abnormal seedlings which may be unnoticed by an inexperienced observer.

SEED INOCULATION

Legume crops add nitrogen to the soil only if their roots are well nodulated with nitrogen-fixing bacteria. When growing legumes on a field for the first time, inoculate the seed immediately before planting. Packaged inoculant for specific crops is available from seed dealers. Peas, lentils, and horse beans are all nodulated by the same bacterial strains. Field beans require a different strain. Inoculants packaged for use on alfalfa and clovers are not effective on grain legumes. Be sure the inoculant is not outdated and follow the instructions on the package.

WEED CONTROL

Use good cropping practices
Sow clean seed
Use herbicides where necessary
Read the label
Do not spread weed seed by machinery or in feed
Cover seed and screenings during transport
Control weeds on non-crop land
Have unknown weeds identified

Crop losses due to weeds are higher than generally recognized. Weeds not only compete for light, moisture, and nutrients during the growth of the crop, but go on to decrease the value of the harvested product.

Results of a survey in the United States showed that of "losses to agriculture" including soil, plant insect, plant disease, livestock, and weed losses, weeds accounted for more than one-third of the total. Similar work has been carried out at the Regina Research Station on specific weeds. Losses in wheat ranged from 15 to 61 percent of total crop value at a cost of $5.55 to $20.55 per acre.

Dollar values presented in the following tables are based on the yield of a hand-weeded check on Regina heavy clay. Losses due to weeds will likely vary with the yield potential of a particular area. Further, the cost of herbicide application to control the weed or the crop yield reduction which could occur as a result of chemical injury has not been taken into consideration. Before applying herbicides, these costs should be subtracted from the "dollar loss" to arrive at the net advantage for herbicide application. It should be emphasized, however, that if a weed is allowed to go to seed, cultivation costs, crop yields, and the percentage of weed infestation will likely be affected for a number of years.

Wild Mustard

(9-Year Average)

Weed Infestation (% of Total Growth)	% Reduction in Grain Yields			Dollar Loss per Ac in Wheat at $1.50/Bu
	Oats	Barley	Wheat	
1-20	14	11	15	5.55
21-40	46	49	35	13.05
41-60	63	69	53	19.80

Note: Yield per acre of hand-weeded controls was 24.9 bu for wheat, 41.3 bu for oats, and 41.9 bu for barley.

Stinkweed

(5-Year Average)

Weed Infestation (% of Total Growth)	% Reduction in Wheat Yields	Dollar Loss per Ac at $1.50/Bu
16	36	17.55
61	51	24.75

Note: Yield per acre of hand-weeded control was 32.6 bushels.

Canada Thistle

(2-Year Average)

Plants per Sq Yd	% Reduction in Wheat Yields	Dollar Loss per Ac at $1.50/Bu
Up to 5	18	6.00
20	61	20.55

Note: Yield per acre of hand-weeded control was 22.4 bushels.

Further Results from Manitoba Demonstrate the Effect of Wild Oat Density on the Yield of Wheat, Barley, and Flax

Wild Oats

Plants per Sq Yd	% Reduction in Grain Yield		
	Barley	Wheat	Flax
10	4	8	23
40	7	16	53
70	14	24	64
160	22	38	76
	Dollar Loss per Ac in Barley at $0.69/Bu Wheat at $1.40/Bu, and Flax at $2.65/Bu		
10	1.24	3.36	10.30
40	2.79	6.72	23.74
70	4.25	10.08	28.67
160	6.83	15.96	34.05

Note: An average infestation of wild oats would range from 60-100 plants per sq yd. Heavy infestations range from 300-500 plants per sq yd.

FACTORS CONTRIBUTING TO A SUCCESSFUL WEED CONTROL PROGRAM

Seeding

Sowing clean seed in a firm, moist seed-bed at the proper depth to promote rapid germination and emergence will usually provide good competition with weeds. The recommended fertilizer practices should also be used to enhance emergence and promote crop vigor. Where a heavy crop of weeds is likely to occur, increase the seeding rate by 25 percent to help provide good crop competition.

Delayed Seeding

Delayed seeding can be used to control early germinating weeds such as wild oats and wild buckwheat. Work the soil to a depth of 2 to 3 inches in the early spring to promote germination. Follow by seeding wheat if growth has occurred by mid-May. Seed barley or Polish rapeseed instead of wheat if seeding is delayed until early June.

Caution: This operation may dry the soil and therefore should not be used when moisture is limited.

New Weeds

When purchasing Registered or Certified seed, growers should REQUEST from the seller INFORMATION RELATIVE TO THE TYPE OF WEED SEEDS PRESENT in the sample. This will eliminate obtaining new weeds that are foreign to a particular farm. Weeds which are foreign to some areas of the province are: cleavers (see photo under rapeseed), nightflowering catchfly, green foxtail, Persian darnel, chickweed, narrow-leaved hawk's-beard, cow cockle, field bindweed, corn spurry, hemp nettle, white cockle, and quack grass.

Cultural Weed Control

Cultural weed control should be used to replace, where feasible, herbicide treatments. In the following crops, post- or pre-emergent cultural weed control can be used.

1. Sunflowers or Potatoes—Post-emergence, weekly cultivations with a drag or flex harrow will give control of annual weed seedlings except under excess moisture condi-

tions. Continue tillage until the crop reaches a height that will prevent further effective tillage operations.

2. Rapeseed and Flax—Both crops are poor competitors against weeds in early growth stages. Therefore, it is important that relatively clean conditions be established before growing this crop. Good summerfallow and seed-bed preparation practices are essential.

3. Control of Perennials—Perennials such as Canada thistle, field bindweed, and quack grass can be more effectively controlled if the spraying operation is followed in 2 to 3 weeks by a tillage operation.

Water Rates

Bromoxynil, dicamba, mecoprop, alone or in mixtures, should be applied in 10 to 12 gallons of water per acre to reduce crop injury and provide adequate coverage of the weed. 2,4-DB should be applied in 15 to 20 gallons of water per acre. MCPA or 2,4-D can be applied at 4 to 5 gallons of water per acre; however, crop injury can usually be reduced by increasing water rates. All other chemicals should be applied at 10 or more gallons of water per acre, with the exception of carbyne, which requires only 5 gallons of water.

Low water rates are generally associated with deformed heads, delayed maturity and, in some cases, decreased yields. Work carried out on flax at the Regina Research Station using 8 ounces of 2,4-D amine indicates that low water rates delay maturity and decrease yields.

Effect of the Amount of Water Used in Spraying Flax

Water Gal/Ac	Delay in Days	Yield Bu/Ac
2.5	7	11
5.0	5	12
15.0	1	14

Stage of Application

For optimum weed control, applications of herbicides should be made in the early stages of seedling weed growth (two- to four-leaf stage).

For crop stages which correspond to recommendations, see Fig. 1.

Soil Moisture

An actively growing plant is important to weed control when using systemic herbicides such as 2,4-D, dicamba, TCA, etc. Ample soil moisture facilitates free movement of water throughout the plant, which will act as a vehicle for translocation of the systemic herbicide. On the other hand, soil moisture does not directly affect weed control when contact herbicides such as bromoxynil are used, since they do not require translocation in the water system of the plant.

Diallate and triallate require good soil moisture for activation.

Wetting Agents

There is no experimental evidence from field tests to show that the addition of wetting agents (such as surfactants, household detergents) to prepared formulations of 2,4-D or MCPA will make these compounds more effective in the control of weeds in cereals.

Sprayer Calibration

All equipment for the application of herbicides should be checked for worn nozzles and calibrated each season. Procedures for the calibration of sprayers for liquid herbicide application and fertilizer attachments for granular herbicide application are as follows:

Sprayer—Fill tank.
—Spray known distance in miles at a constant speed.
—Refill tank measuring gallons used.
—Calculate:

$$\text{Number of acres sprayed} = \frac{\text{width of boom (inches)} \times \text{miles travelled}}{100}$$

$$\text{Gallons/acre} = \frac{\text{gallons used}}{\text{acres}}$$

Granular Applicator—

$$\text{Calculate pounds/acre} = \frac{\text{total pounds granules metered} \times 43560}{\text{width of cut (feet)} \times \text{distance travelled (feet)}}$$

Fall Spraying for Winter Annuals

Three winter annuals, smartweed, shepherd's-purse, and flixweed, begin to show as seedlings in late September or early October. Spraying these seedlings with 2,4-D ester or amine at 5 to 6 ounces per acre any time before snow cover will facilitate control the following spring. This operation will save time, cost less than cultivation, prevent erosion, and conserve soil moisture. (See Cropping Practices section, illustrated on page 131.)

Rate of Herbicide Application

For most weed species a range of rates is given. **The lowest rates in the range should be used ONLY on seedling weeds under good growing conditions. Use the higher rates if** the weeds have reached an advanced stage of growth, or under adverse growing conditions, or on extremely heavy infestations of weeds. **Fields are rarely infested with a single weed species, therefore apply enough of the right type of herbicide to give satisfactory control of the most resistant species.**

Herbicide Mixtures

When all species cannot be controlled by one herbicide it may be necessary to apply a mixture of herbicides. Some formulations do not mix together well. Commercially prepared mixtures are on the market. These should be used in preference to mixtures prepared by the farmer.

Efficient Use of Herbicides

To get the maximum benefit from herbicides, every effort should be made to minimize injury caused by chemicals. Select the chemical least likely to cause crop injury and apply at the "safe" stage. The key to effective control of annual weeds is early treatment. Weeds are most susceptible to herbicides when they are in the seedling stage. Remove weeds early to avoid serious crop losses from weed competition.

Precautions to Observe in Using Herbicides—Crops such as mustard, rapeseed, sunflowers, many horticultural crops, and trees such as Manitoba maple and Siberian elm, are very sensitive to small amounts of 2,4-D or MCPA. Droplets of either ester or amine solutions may be carried by the wind for several miles before reaching the ground. Do not spray when the wind is blowing toward trees or sensitive crops. Drift can be reduced by holding sprayer pressure at 30 psi and by using larger tips (nozzles) to increase the water rate applied.

Esters of 2,4-D and MCPA present an additional hazard. These forms may give off vapors after the herbicides have been applied. The danger is especially great if temperatures are high after application. Vapors may be carried in any direction depending on the wind, after the time of applica-

tion. As a precaution use only amine, or possibly, low volatile ester forms of 2,4-D or MCPA, within a quarter of a mile of sensitive trees or crops.

Mustard, Rapeseed, and Sunflower—Before using spray equipment to apply herbicides to rapeseed, mustard, or sunflower, it should be cleaned of any traces of herbicides such as 2,4-D, MCPA, or dicamba.

Cleaning the Sprayer—To remove esters of 2,4-D or MCPA the following cleaning procedure should be followed: a. Run clean water through the pump, tank, etc.; b. remove and clean nozzles and screens in kerosene; c. with boom shut off run 5 to 10 gallons of kerosene through the pump, lines, and tank for 10 to 15 minutes, then flush through the boom; d. fill tank with solution of 2.5 pounds of sodium carbonate, 1 cup of detergent, and 3 gallons of kerosene per 50 gallons of water; e. circulate this solution through pump, lines, etc., and allow to stand overnight; f. remove and rinse thoroughly (rubber hoses are very difficult to clean); and g. apply new pesticide solution as soon as possible after mixing. The last step minimizes time for herbicide residues in the tank to dissolve in the new solution.

Sprayers in which only amine or sodium salt forms have been used should be cleaned as follows: a. Run clean water through pump, tank, lines, etc.; b. remove nozzles and screens and wash separately; c. fill tank with a solution of 1 gallon of household ammonia to 100 gallons of water; d. circulate this solution through pump, lines, etc., and allow to stand overnight; and e. remove solution and rinse thoroughly with water.

Recommendations for the Use of Herbicides in Field Crops

The herbicide treatments listed here are only a portion of those approved for use in 1972. Full details on herbicide treatments cannot be given because of the limited space available. Complete directions on kind and amount of carrier, time of application, and specific precautions can be found on the labels. These instructions must be followed carefully. All herbicides are referred to by the common names which have been adopted by the Canadian Standards Association and which appear on the labels in the guarantee of active ingredient. **All rates given here are in terms of active ingredient.**

No herbicide will control all weeds under all circumstances and conditions. Select the most appropriate herbicide and apply at the correct rate, time, and under the best conditions possible. The recommendations made here will be successful under most conditions; however, under extreme environmental conditions, such as wind, temperature, or moisture, treatments may not be successful. Uneven germination of weeds often leads to poor results. The recommendations made here are sometimes more restrictive than those on the label because they are modified to suit Saskatchewan conditions.

WEED CONTROL IN CEREAL CROPS

Chemicals and Application Procedures

2,4-D and MCPA—Wheat and barley may be injured and maturity delayed by these herbicides. The most tolerant period extends from the four-leaf up to the shot-blade stage of growth. (See Fig. 1.) 2,4-D and MCPA at rates over 8 ounces per acre may cause injury at all stages. **Treatment at the four-leaf stage will usually combine good crop tolerance and maximum weed susceptibility.** 2,4-D applied before the four-leaf stage may result in deformed leaves and heads. This may reduce yields. MCPA and 2,4-D amine cause less damage than 2,4-D esters. Applications made during the shot-blade stage and up to the fully headed stage will usually cause sterility and serious yield losses.

Oats can be seriously injured by 2,4-D. Esters or amines of MCPA, however, can be applied at any time before the shot-blade stage. This crop should not be treated with 2,4-D except when necessary to control heavy infestations of MCPA-resistant weeds such as Russian thistle. If 2,4-D must be used, amine form rather than the ester form should be applied either before the three-leaf stage or between the six-leaf and shot-blade stages.

Fall Rye can be treated in early spring with 2,4-D or MCPA. For the control of winter annuals, stinkweed, flixweed, and shepherd's-purse, apply 2,4-D at 4 to 6 ounces per acre in late September or early October.

Dicamba (Banvel)—Dicamba is available as a separate product to be used for specific weed problems or for tank mixing with amines of 2,4-D or MCPA on the farm. Rates of 2,4-D or MCPA and dicamba in the tank mix can be regulated to fit the type of weed problem in the field. However, the rate of dicamba should not exceed 2 ounces per acre for wheat and oats and 1.5 ounces per acre for barley.

Dicamba + 2,4-D + Mecoprop Mixture (Banvel 3)—Dicamba is available in mixture with 2,4-D and mecoprop at a ratio of 1.8:5.0:1.2. Rates given here are for total acid equivalent of all ingredients in the mixture. This mixture should be applied from the two- to the five-leaf stage of wheat and oats to obtain maximum crop safety. Rates above 8 ounces per acre may cause injury. Barley is more sensitive than wheat and oats to dicamba. Dosage on barley should never exceed 6 ounces per acre and treatment should not be made after the three-leaf stage.

Bromoxynil + MCPA Mixture (Brominal-M, Buctril-M)—Bromoxynil is available in a mixture with MCPA at a 1:1 ratio. Rates given here are for total acid equivalent. This mixture can be applied to spring wheat, oats, and barley from the two-leaf up to the shot-blade stage at rates up to 16 ounces per acre. Poor results may be obtained if the crop cover prevents the spray from contacting the weeds.

Dichlorprop + 2,4-D Mixture (Estaprop)—Dichlorprop is available in 1:1 mixture with 2,4-D. Rates given are for total acid equivalent. This mixture can be applied to wheat and barley from the four-leaf up to the shot-blade stage of growth at 12 to 16 ounces per acre.

Control of Specific Weeds in Cereal Crops

Lamb's-Quarters, Ball Mustard, Hare's-Ear Mustard, Indian Mustard, Tumble Mustard, Tall Wormseed Mustard, Wild Mustard, Common Ragweed, False Mustard, Giant Ragweed, Stinkweed, Prairie Sunflower—Apply 2,4-D or MCPA (ester or amine) at 4 to 6 ounces per acre.

Stinkweed, Flixweed, Shepherd's-Purse—Plants that germinate in the fall or late summer are hard to kill the next spring. They should, therefore, be killed by cultivation or by an application of 2,4-D ester or amine at 5 to 6 ounces per acre **in the fall** before freezeup. Fall spraying leaves stubble standing, which in turn conserves soil moisture and reduces soil erosion. (See Cropping Practices section, illustrated on page 131.)

Winter annuals that are not killed by cultivation at seeding time are resistant to herbicides by the time the crop reaches the proper stage for spraying.

Russian Thistle—Apply 2,4-D ester at 6 to 8 ounces per acre or 2,4-D amine at 8 to 12 ounces per acre. MCPA will not control this weed.

Dog Mustard, Green Tansy Mustard, Redroot Pigweed, Pale Smartweed, Green Smartweed, Field Pepper-Grass, Tumbleweed, Biennial Wormwood, and Topgrowth of Canada Thistle, Perennial Sow-Thistle, Field Bindweed, Blue Lettuce—In wheat and barley apply 2,4-D ester at 8 to 12 ounces per acre or amine at 12 ounces per acre when the weeds are in the early stages. These rates may injure wheat and barley but, generally, yields are not seriously reduced. In heavy weed infestations the benefits from reduced weed competition will often more than offset the damage. In oats apply MCPA (ester or amine) at 10 to 14 ounces per acre when the weeds are in the early seedling stage. At equivalent rates, MCPA does not control weeds as effectively as 2,4-D but it is much safer to use on oats at these relatively high rates.

Hemp Nettle—Mixtures of MCPA + 2, 4, 5 - T (at 3 to 5 ounces per acre) at a total of 8 to 12 ounces per acre applied when the weed has two to four leaves will give about 90-percent kill without serious injury to wheat, oats, or barley, or MCPA at 8 to 12 ounces per acre applied at the two- to four-leaf stage will suppress growth. Although complete control of hemp nettle may not be obtained, the crop yield will be increased. In crops underseeded with alfalfa or clovers apply MCPB at 20 to 24 ounces per acre to suppress the growth of hemp nettle.

Horsetail, Field—to control topgrowth apply an ester of MCPA at 5 to 7 ounces per acre after the weed has fully emerged.

Cow Cockle—In wheat or oats, apply dicamba + 2,4-D + mecoprop mixture at 8 ounces per acre or bromoxynil + MCPA mixture at 10 to 12 ounces per acre, or mixtures of dicamba at 2 ounces per acre + 6 ounces per acre of 2,4-D. Treat when the weed is in the two- to four-leaf stage. Applications made after the four-leaf stage will seldom give effective control.

Pale Smartweed and Green Smartweed—At the two- to four-leaf stage of the weeds, in wheat, oats, or barley, apply bromoxynil + MCPA mixture at 8 to 12 ounces per acre, or in wheat or oats, apply dicamba + 2,4-D + mecoprop mixture at 8 ounces per acre, or dicamba alone at 1.5 to 2.0 ounces per acre, or in wheat or barley apply dichlorprop + 2,4-D mixture at 16 ounces per acre.

Wild Buckwheat—In wheat, oats, or barley, apply bromoxynil + MCPA mixture at 8 to 12 ounces per acre when the weed is in the two- to four-leaf stage.

Or, in wheat and oats, apply dicamba + 2,4-D + mecoprop mixture at 8 ounces per acre or dicamba alone at 1.5 to 2 ounces per acre, when the weed is in the two- to three-leaf stage.

Or, in wheat or barley, apply dichlorprop + 2,4-D mixture at 16 ounces per acre, when the weed is in the two- to four-leaf stage and the crop in the four-leaf stage.

Corn Spurry, Chickweed, Plantain—In wheat only, apply mecoprop at 12 to 16 ounces per acre in the early stages of weed growth and at the three- to five-leaf stage of crop development.

Tartary Buckwheat—In wheat, oats, or barley, apply bromoxynil + MCPA mixture at 8 to 12 ounces per acre when the weed is in the two- to four-leaf stage; or, in wheat and oats, apply dicamba + 2,4-D + mecoprop mixture at 8 ounces per acre, or dicamba alone at 1.5 to 2 ounces per acre; or, in wheat and barley apply dichlorprop + 2,4-D mixture at 16 ounces per acre.

Apply an ester of 2,4-DB at 24 ounces per acre to suppress the growth of tartary buckwheat in grain undersown with alfalfa.

Wild Oats—After wheat is seeded, apply triallate at 1.25 pounds per acre. After barley is seeded, apply triallate at 1.25 to 1.5 pounds per acre or diallate at 1.25 pounds per acre. Wheat and barley should be seeded at a depth of 3 inches. The herbicides should be applied in 10 gallons of water per acre at a pressure of 30 psi and incorporated into the soil to a depth of 2 inches by double harrowing the day of application. If the soil has a heavy trash cover, two discing operations are suggested. If incorporation is delayed, a considerable amount of herbicide will be lost, especially under hot or windy conditions.

Or, triallate can be applied with a discer-mounted sprayer with boom attached to the rear of the discer and carefully adjusted so that the action of the discer incorporates the herbicide shallowly at the same time seeding is done. This allows seeding and spraying in one operation. Subsequent harrowing is not necessary, but the usual packing after seeding should be done.

Damage to wheat can be expected on heavy clay soils or on soils low in organic matter unless the seed is sown half an inch below the treated layer of soil. The chemical is inactive if the top few inches of soil are dry. Rain is then needed for activation. Avoid pre-seeding tillage, which tends to dry the surface layer. A heavy straw cover may make good incorporation of the chemical difficult.

On land where barley or wheat will be sown, triallate—liquid or granular—can be applied in late fall 2 to 3 weeks before freezeup. Incorporate both chemicals in the fall. The liquid formulation should be incorporated immediately. The main advantage of the granular formulation is that it can be applied with a trash cover present.

In barley, spring wheat, and durum wheat, apply barban at 4 to 5 ounces in 5 gallons of water per acre at a pressure of at least 45 psi when most of the wild oats are in the two-leaf stage. Effective control depends on uniform emergence of the weed. Best results are obtained when the wild oats crop is growing fast enough to reach the two-leaf stage in less than 11 days after emergence. The 4-ounce rate is recommended for infestations up to 150 wild oat plants per square yard. The higher rate should be used in heavier infestations, or under adverse growing conditions. Wheat and barley may be damaged if barban is applied 14 or more days after emergence, or if the crop has passed the three-leaf stage. Barban kills or stunts the wild oat plants, thereby reducing competition with the crop. The killing is gradual and may not be evident for 2 to 3 weeks after spraying.

Green Foxtail—Apply TCA in 8 to 10 gallons of water per acre at 1 pound per acre in barley and 1 to 2 pounds per acre in oats when the weed is in the one- to three-leaf stage and the crop is in the two- to four-leaf stage. Use the 1 pound per acre rate on sandy soils. TCA may be mixed with MCPA amine. Since TCA acts primarily through the soil, best results will be obtained on sandy soils and under good moisture conditions.

WEED CONTROL IN OTHER ANNUAL CROPS

Flax

Chemicals and Application Procedures for Flax

MCPA and 2,4-D—Apply MCPA or 2,4-D from the time flax is 2 inches tall until just before bud formation. Spray as soon as enough weeds emerge to make it practical, as early spraying results in better weed control and less risk of crop injury. Crop injury and delay in maturity can be reduced by increasing the volume of water up to 10 to 15 gallons per acre. This is important when spraying at an advanced stage of the flax, when using herbicides at high rates, or when using ester formulations. (See Water Rates, page 70.)

Control of Specific Weeds in Flax

Ball Mustard, Hare's-Ear Mustard, Indian Mustard, Tumble Mustard, Wild Mustard, Tall Wormseed Mustard,

Stinkweed, Lamb's-Quarters—Apply an ester of MCPA at 4 to 6 ounces per acre, MCPA amine at 5 to 7 ounces per acre, or a sodium salt of MCPA at 6 to 8 ounces per acre.

Cocklebur, Flixweed, Kochia, Prickly Lettuce, Russian Pigweed, Common Ragweed, False Ragweed, Giant Ragweed, Shepherd's-Purse—Apply ester of MCPA at 6 to 8 ounces per acre, MCPA amine at 7 to 9 ounces per acre, or sodium salt of MCPA at 8 to 10 ounces per acre.

Oak-Leaved Goosefoot, Common Groundsel, Green Tansy Mustard, Hemp Nettle, Prostrate Pigweed, Redroot Pigweed, or Topgrowth of Perennial Sow Thistle, Canada Thistle, Field Bindweed, Curled Dock, Field Dock, Blue Lettuce—Apply ester of MCPA at 9 to 12 ounces per acre, or MCPA amine at 10 to 14 ounces per acre, or sodium salt of MCPA at 12 to 15 ounces per acre.

Some delay in maturity should be expected when flax is treated with an ester of MCPA at six or more ounces per acre, MCPA amine at seven or more ounces per acre, or MCPA sodium salt at eight or more ounces per acre, but this will usually be offset by increased yields due to weed control.

Russian Thistle—As an emergency treatment apply 2,4-D ester at 6 to 8 ounces per acre or 2,4-D amine at 7 to 9 ounces per acre in 10 to 15 gallons of water per acre. Some injury to flax as well as some delay in maturity should be expected.

Wild Buckwheat, Green Smartweed, Russian Thistle, Lady's Thumb, Redroot Pigweed, Cowcockle, and Tartary Buckwheat—Apply a 1:1 mixture of bromoxynil + MCPA at 8 ounces per acre in 10 gallons of water per acre. For best weed control and least crop injury, spray when the flax is 2 to 4 inches high and the weeds are small. Spraying in hot, humid weather should be avoided.

Wild Oats—Apply diallate (Avadex) at 1.5 to 2 pounds in 10 gallons of water per acre before seeding. Incorporate the chemical into the soil to a depth of 2 to 3 inches immediately after spraying. Incorporation may be done with a disc-type implement; two disc operations are suggested if the soil has a heavy trash cover. On well-worked land, a double harrowing may be satisfactory. Prepare a firm seed-bed. Sow the flax at a depth of 2 inches in moist soil. Diallate can also be applied in late fall 2 to 3 weeks before freezeup.

Or, apply barban at 4 to 5 ounces in 5 gallons of water per acre, at a pressure of at least 45 psi, when most of the wild oats are in the two-leaf stage. Effective control depends on uniform wild oat emergence. The higher rate should be used on heavy infestations and under poor growing conditions. Flax may be injured if it is sprayed before the appearance of true leaves or after the 12-leaf stage.

Green Foxtail—Apply dalapon at 0.75 to 1.25 pounds per acre or TCA at 4 to 6 pounds per acre when the weed is in the one- to three-leaf stage and preferably when the flax is 4 to 6 inches tall. Use 10 to 15 gallons of water per acre. Dalapon or TCA may be mixed with MCPA amine for control of green foxtail and broad-leaved weeds.

Mustard

Control of Specific Weeds

Wild Oats—Use diallate as recommended for flax, or apply barban at 4 to 5 ounces per acre when the wild oats are at the two-leaf stage. (See Cleaning the Sprayer, page 71.)

Wild Oats, Green Foxtail, Barnyard Grass, Wild Buckwheat, Redroot Pigweed, and Lamb's-Quarters—Apply trifluralin at 0.75 to 1.0 pound per acre, preplant in 10 gallons of water, and incorporate to a depth of 2 to 3 inches.

Wild Buckwheat, Green Smartweed, Redroot Pigweed, and Lamb's-Quarters—Apply nitrofen at 1.2 pounds per acre early post-emergence in 10 gallons of water per acre. To achieve control of weeds it is important to make applications in the two- to four-leaf stage of weed growth.

Rapeseed

Wild Oats—Apply diallate (Avadex) at 1.5 to 2.0 pounds per acre before planting in 10 gallons of water per acre, incorporate the same day by discing or double harrowing 1.5 to 2 inches deep. Use the heavier rate on heavy infestations.

Or, apply barban at 4 to 5 ounces per acre in 5 gallons of water per acre at 45 psi when majority of weeds are in the two-leaf stage. Nozzles should be directed forward at 45°.

Green Foxtail—Apply TCA at 2 to 4 pounds per acre or dalapon at 0.75 to 1.25 pounds per acre in 10 gallons of water per acre (minimum) when weeds are in the one- to three-leaf stage and the crop has two to four true leaves. Use a lower rate of chemical on sandy soils. Rates of dalapon in excess of 1.25 pounds per acre will cause severe yield reduction.

Wild Buckwheat, Green Smartweed, Redroot Pigweed, Lamb's-Quarters—Apply nitrofen (TOK/RM) at 1.2 pounds per acre in ten or more gallons of water per acre when weeds are in the two- to four-leaf stage. Good coverage is required for control.

Barnyard Grass, Green Foxtail, Wild Oats, Wild Buckwheat, Lamb's-Quarters, Redroot Pigweed, Prostrate Pigweed—Apply trifluralin at 12 ounces per acre (sandy soil) or 16 ounces per acre (loam and clay soil), before planting, in 10 gallons of water per acre. Incorporate immediately and thoroughly to a depth of 3 to 4 inches with a discer or mulch treader. The lighter rate may be used on soils below 6 percent organic matter and the higher rate on higher organic soil. Or, apply trifluralin in the fall at 1 to 1.25 pounds per acre.

Wild Mustard—Apply benazolin at 8 to 12 ounces per acre in 5 to 10 gallons of water per acre when crop is in the two- to four-leaf stage. Results with this product are not consistent. It is recommended that it be applied only in emergency situations.

Cleavers—Cleavers produce a seed which is not easily separated from rapeseed. For this reason samples of rapeseed have been rejected. When purchasing rapeseed for seed, information relative to weed seed content should be obtained from the seller to avoid contaminating more fields with cleavers. (See New Weeds, page 69.) Cleavers can be recognized by a square stem covered with backward pointing bristles. If you have this weed in your rapeseed, contact your agricultural representative. (See Figs. 2 and 3.)

Sunflowers

Broadleaved Weeds or Grasses—Apply EPTC at 3 pounds per acre as a preplanting incorporated treatment.

Wild Oats—Apply diallate at 1.5 to 2 pounds per acre preplanting or in the fall in 10 gallons of water per acre. Disc immediately. Fall tillage may increase the hazard of soil erosion.

Or, apply barban at 4 to 6 ounces per acre when the majority of wild oats are in the two-leaf stage.

Lamb's-Quarters, Redroot Pigweed, Prostrate Pigweed, Wild Buckwheat, Wild Oats, Barnyard Grass, Green Foxtail—Apply trifluralin at 16 ounces per acre in 10 gallons of water per acre. Incorporate immediately to a depth of 3 to 4 inches by cross-discing.

Or, fall apply trifluralin (early September to freezeup) at 1.0 pound per acre on light soils and 1.25 pounds per acre on medium to heavy soils.

Field Corn

Broad-Leaved Annual Weeds—Apply 2,4-D amine at 6 to 8 ounces in 15 to 20 gallons of water per acre. Rates over 8 ounces per acre may cause injury. After the corn is 6 inches tall, the spray solution should be directed at the weeds in the bottom of the row. The tops of the corn should not be sprayed.

Annual Grasses and Broad-Leaved Weeds—Apply linuron at 1.5 pounds per acre in 20 to 30 gallons of water per acre as a pre-emergent treatment or after the corn is 15 inches tall as a directed spray on weeds. Or, apply dinoseb at 3 to 4.5 pounds per acre in 30 to 50 gallons of water per acre. Dinoseb may be applied from just before emergence until the corn is 1-inch tall.

WEED CONTROL IN FORAGE CROPS

Grasses

To control broad-leaved weeds in most seedling grasses, apply 2,4-D or MCPA amine at up to 8 ounces per acre any time after the grasses have reached the three-leaf stage. Applications may also be made in the fall or early spring **before** seeding to control winter annuals.

In established stands of forage grasses, esters or amines of 2,4-D or MCPA may be applied at rates up to 24 ounces per acre. If a seed crop is to be harvested the rate of herbicide application should not exceed 16 ounces per acre or be applied after the start of the shot-blade stage.

Seedling Legumes

Seedling legumes are most resistant to 2,4-DB and MCPB during the one- to three-trifoliate leaf stage. They should not be sprayed after reaching 6 to 8 inches in height. A good canopy formed by the companion crop and weeds will reduce the risk of injury. Herbicides should be applied in 15 to 20 gallons of water per acre. In alfalfa, apply 2,4-DB at 16 to 20 ounces per acre; for alsike, red clover, white clover, and sainfoin, apply MCPB at 16 to 20 ounces per acre. For sweet clover, 2,4-D, MCPA, 2,4-DB, and MCPB are not recommended.

In dry areas, before seeding legumes and grasses into stubble, apply 2,4-D at 6 to 8 ounces in 4 or more gallons of water per acre to control broad-leaved weeds that have already emerged.

Grasses and Broad-Leaved Weeds in Seedling Alfalfa and Bird's-Foot Trefoil—Apply EPTC at 2 to 3 pounds per acre prior to planting alfalfa and incorporate immediately.

Green Foxtail in Pure Stands of Alfalfa or Sweet Clover—Apply dalapon at 0.75 to 1 pound per acre or TCA at 3 to 4 pounds per acre both in 8 to 10 gallons of water per acre.

Established Alfalfa

Stinkweed, Flixweed, Shepherd's-Purse, Narrow-Leaved Hawk's-Beard—Apply an ester of 2,4-DB at 12 to 16 ounces for control of stinkweed, flixweed, and shepherd's-purse and at 16 to 20 ounces per acre for control of narrow-leaved hawk's-beard in 15 to 20 gallons of water per acre. Apply in the fall after the weeds have emerged and formed a rosette. If alfalfa is more than 8 inches in height, spraying should be undertaken after the alfalfa has been killed by frost.

Russian Pigweed, Biennial and Winter Annual Broad-Leaved Weeds—Apply MCPA or 2,4-D amines at 8 to 16 ounces per acre before growth of alfalfa or grasses begins in the spring.

Canada Thistle and Perennial Sow Thistle—In pasture, apply 2,4-DB at 16 to 20 ounces per acre after grazing and before alfalfa exceeds 3 inches in height. Damage to the alfalfa is likely to increase the longer the treatment is delayed beyond the 3-inch stage. Best control of these thistles will result from treating before flowering.

In hay, treat after the second cut with 2,4-DB at 16 to 20 ounces per acre before growth of alfalfa or grasses begins.

Rangeland and Native Pastures

The carrying capacity and quality of forage on range or native pastures can be increased by weed control. Overgrazing weakens the desirable forage species, making it difficult for them to compete with weeds.

Poisonous plants that are normally not eaten by livestock may become palatable when treated with herbicides. Watch for poisonous plants and destroy them by pulling or cultivation before the patches become large.

Make herbicide application in early summer as soon as leaves of weeds are fully expanded. Apply in 10 to 15 gallons of water per acre from ground rig or in at least 3 gallons of water per acre by aircraft. A mixture of 9 parts water to 1 part diesel fuel can be used as the carrier with some ester formulations.

Willow, Alder, Chokecherry, Saskatoon, Gumweed—Apply an ester of 2,4-D at 16 to 32 ounces per acre.

Aspen Poplar, Western Snowberry, Silverberry, Lupines, Locoweed, Water Hemlock—Apply an ester of 2,4-D at 32 ounces per acre.

Rose, Dogwood, Raspberry, Hawthorn, Green Ash, and the Above Species—Apply a 2:1 mixture of 2,4-D + 2,4,5-T at 32 ounces per acre.

With all of the above, retreatments will be necessary.

If trees are 20 to 40 feet tall, they can be bulldozed or knocked down with equipment (ball and chain or rails) developed for this purpose. Best results are obtained when the temperature is below minus 20°F. If the ground is frozen, the fallen trees can be pushed into windrows by bulldozers. Otherwise, use piler equipment to minimize soil disturbance. When brush is less than 10 feet tall, it can be knocked down with a rotary brush cutter. Regrowth from the roots of some trees, such as aspen poplar, should be sprayed in June.

After the removal of brush, the carrying capacity will be increased as the native grasses and other plants take over. Yields can be greatly increased if alfalfa and brome grass or crested wheat grass become established. It is usually necessary to wait 3 or 4 years before stumps have rotted enough to allow preparation of a good seed-bed. Even then, heavy disc equipment is needed. Do not seed alfalfa if brush regrowth is going to need spraying.

WEED CONTROL IN HORTICULTURE CROPS

Every effort should be made to prevent annual weeds from producing seeds in garden areas. In general, this requires diligent hand-weeding, hoeing, and cultivation. In prairie areas, it is advisable to summerfallow half of the garden each year. Do not attempt to grow vegetables or flowers in areas infested with perennial weeds.

Herbicides can be used to control weeds in certain vegetable crops in addition to those recommended below. For further information, see Saskatchewan Department of Agriculture publication, **Chemical Weed Control in Vegetables and Small Fruits in Saskatchewan.** Extreme care must be taken to follow the directions on the label.

Carrots

Annual Weeds and Seedling Grasses—Apply linuron (Afolan, Lorox) at 1 to 2 pounds per acre in 30 to 50 gallons of water per acre either pre-emergence to crop and weeds, or after carrots have formed first true leaves, and weeds are less than 4 inches and grasses less than 2 inches tall. The 2 pounds per acre rate post-emergence should only be used where a protective weed canopy covers the carrots; otherwise, growth of carrots is retarded. There may be some injury from linuron if heavy rains occur at emergence of the carrots. Do not use linuron on sandy soils.

Or, apply Stoddard solvent (selective oil) at 60 to 80 gallons per acre after the first true leaves appear on the carrots. Use the lower rate in hot weather to avoid injury. Apply no later than 30 days before harvest.

Potatoes

Seedling Annual Grasses and Broad-Leaved Weeds — Apply paraquat (Gramoxone) at 4 to 8 ounces per acre when grass and broad-leaved weeds are in the early stages of seedling growth. This application should be made pre-emergence to potatoes or up until 10 percent of the potatoes have emerged.

Or, metabromuron (patoran) at 1.5 to 3 pounds per acre pre-emergence to potatoes and weeds or at weed emergence. Use not more than 2 pounds per acre on sandy soils; 3 pounds per acre may be required on organic soils.

Common Chickweed, Corn Spurry, Stinkweed, Green Foxtail, Groundsel, Kochia, Prostrate Pigweed, Redroot Pigweed, Purslane, Shepherd's Purse, Wild Buckwheat, Mustard—Apply 1 to 2 pounds per acre linuron (Afolan, Lorox) or monolinuron (Afsin) pre-emergence to potatoes and in the early stages of seedling weed growth. Linuron or monolinuron may also be applied pre-emergence to weed growth but requires moisture for activation.

Wild Oats—Apply diallate (Avadex) at 1.5 to 2 pounds per acre as a preplant application. Thoroughly incorporate to a depth of 2 to 2.5 inches.

Quack Grass—Apply dalapon at 12 to 15 pounds per acre before tillage in the spring and when quack grass is 4 to 6 inches tall. Dalapon should not be used on red skinned varieties.

Sweet Corn (See Field Corn, page 73.)

Tomatoes

Apply solan at 4 pounds per acre to control annual broad-leaved weeds in established transplants. This is a post-emergence treatment but application should be made when weeds are small. A repeat application may be made if necessary.

Raspberries

To kill annual weeds and knock down topgrowth of perennial weeds, apply paraquat (Gramoxone) at 1 to 2 pounds per acre or dinoseb at 6 pounds per acre. Direct sprays toward the base of plants. This should be done in the early spring before new canes emerge. To control quack grass, apply dalapon at 10 pounds per acre in the early fall. Direct the spray at the quack grass foliage and away from the raspberry canes.

Tree Fruits

Apply paraquat at 1 to 2 pounds per acre. In the year of planting apply paraquat at 1 pound per acre as a shielded spray to avoid contact with the trees. Apply in approximately 100 gallons of water per acre when weeds are 6 to 8 inches tall. For best results use paraquat in the evening or on dull days. Repeat applications will be necessary.

WEED CONTROL ON LAWNS

Herbicides for the control of weeds in lawns should be considered a supplement to good lawn management. Weeds can often be controlled by fertilization, watering, and mowing at a height of 1.5 to 2 inches. Best results are obtained when herbicides are applied in early fall. Herbicides can also be applied in the spring, but weeds are more resistant then and there is a greater chance of injuring nearby susceptible plants. Also, there are not many days in the early spring on which temperature and wind conditions are favorable for spraying. Applications must be made each year to control newly established weeds.

To avoid injury to bedding plants, tomatoes, etc., herbicides such as 2,4-D should be used with extreme caution. To minimize the danger of spray drift, apply the herbicide solutions at low pressures (25 to 30 psi) and in high volumes of water (50 to 100 gallons per acre). Apply only when air is moving away from susceptible plants. Use only amine salts.

Annual Broad-Leaved Weeds in Newly Seeded Lawns—Repeated mowing will control most of these weeds. Or, apply 2,4-D amine at 0.2 ounce per 1,000 square feet (0.5 pounds per acre) after the grass seedlings have three leaves.

Dandelion, Plantain—Apply 2,4-D at 0.4 ounce per 1,000 square feet (1 pound per acre) annually.

White Clover, Black Medick, Creeping Bellflower, Common Chickweed, Mouse-Eared Chickweed, Field Chickweed—Apply mecoprop or fenoprop at 0.6 ounce per 1,000 square feet (1.5 pounds per acre) annually.

WEED CONTROL IN SHELTERBELTS

Caragana, Siberian Elm, American Elm, Green Ash, Manitoba Maple, Scots Pine, White Spruce, Colorado Spruce

Apply trifluralin at 2 to 4 pounds in 30 to 50 gallons of water per acre prior to tree planting. This chemical must be thoroughly incorporated in the top 3 to 4 inches of soil immediately after application. This will provide seasonal control of most annual weeds; however, stinkweed and wild mustard may not be controlled at these rates.

Or, apply linuron at 2 to 4 pounds in 30 to 50 gallons of water per acre before or immediately after weeds emerge. If leaf buds have not broken, the chemical may be applied as an overall spray. If buds have broken, the spray must be directed to the base of the tree to avoid contacting new foliage. If weeds are 4 to 6 inches tall, a non-herbicidal oil (such as Ag-Oil or Niagara Brand oil) at 2 gallons per acre should be added to the above rate of linuron and applied as a directed spray. Linuron may be used on poplar and willow plantings as well as those mentioned above. Normally, control of annual weeds may be expected to last for the remainder of the season. Poor results may be obtained under dry conditions.

Or, apply paraquat at 1 to 2 pounds in 50 to 100 gallons of water per acre. It must be applied as a directed spray to avoid contact with tree foliage. Special care must be taken with conifers, since damaged needles will be lost permanently. The foliage of the weeds must be thoroughly wetted. Paraquat kills annual weeds and the topgrowth of grasses and other perennials. It has no residual effect. Repeated applications will be required during the growing season, particularly for the control of perennial weeds and grasses.

Or, soil under which trees which have been established in one growing season or more may be treated with simazine at 2 to 4 pounds in 30 to 50 gallons of water per acre. Do not use on coarse-textured soils. Replacement trees may be injured if planted in simazine-treated soil. Therefore, do not apply simazine until after replacement trees have been planted. Control of annual weeds by simazine may be expected for the remainder of the season and may continue into the following year. Simazine may also be applied in the fall. Apply only to soil free of weeds and trash. Simazine at the above rates will not kill perennial weeds. Use the higher rates on clay soils and on soils high in organic matter and the lower rates on soils that are low in organic matter. Simazine is not recommended for use on sandy- or coarse-textured soils.

LONG-TERM PROBLEMS FOR PERENNIAL WEED CONTROL

Canada Thistle, Perennial Sow Thistle—One season of thorough summerfallow will control thistles in some years.

Tillage must be frequent enough to prevent regrowth from appearing for more than 1 week. Shoots should be cut off 2 to 4 inches below the soil surface at every operation.

To preserve trash or if it is too wet to cultivate, 2,4-D or MCPA at 16 ounces per acre, or dicamba + 2,4-D + mecoprop mixture at 8 ounces per acre can be used instead of tillage during the summerfallow operations. Cultivate early in the season to destroy annual weeds and volunteer grain. Allow the thistles to reach the early bud stage before applying the herbicides. Cultivate again as soon as the thistles show signs of regrowth.

The following year, spray the thistles in the crop. In wheat and barley, apply an ester or amine of 2,4-D or MCPA at 8 to 12 ounces per acre. These rates of MCPA or 2,4-D may injure the grain. Delay the application until the maximum number of thistle shoots has emerged, but apply before the shot-blade stage of the grain.

Or, in wheat and oats, apply a dicamba + 2,4-D + mecoprop mixture at 8 ounces per acre at the three- to five-leaf stage of the crop. Regrowth in the stubble should be sprayed or cultivated shortly after harvest.

In cereals seeded down to alfalfa, red clover, or white clover, apply an ester of 2,4-DB at 24 ounces per acre from the four-leaf up to the shot-blade stage.

On non-cropland, apply 2,4-D at 2 pounds per acre, or dicamba + 2,4-D + mecoprop mixture at 2 pounds per acre, or dicamba alone at 1 pound per acre, or picloram (Tordon) at 0.5 to 1 pound per acre, when the thistles reach the bud stage. Use 30 to 50 gallons of water per acre or enough to completely cover the thistle plant. These treatments may injure but will not destroy grasses.

Nodding Thistle—Apply 2,4-D ester or amine at 16 ounces per acre in the spring (June) and again in the fall (September).

Field Bindweed, Hedge Bindweed—To increase the effectiveness of the herbicide treatment, start summerfallow tillage when the weeds emerge in the spring. Cultivate whenever regrowth is 1 to 3 inches long. About mid-July allow the bindweed to grow undisturbed until it reaches the early bud stage. Then apply an ester of 2,4-D at 12 to 16 ounces per acre. When regrowth occurs, resume cultivation and continue as required until freezeup. Plant wheat or barley the following spring and spray the bindweed in the crop with an ester of 2,4-D at 8 ounces per acre. Immediately after harvest cultivate or spray with 2,4-D at 12 to 16 ounces per acre. Repeat this rotation.

Small Patches—Two years of intensive cultivation will usually eliminate these weeds. Sodium chlorate or sodium borate, at 3 to 4 pounds per 100 square feet, or 2,3,6-TBA at 10 pounds per acre applied in the spring, or 2 to 4 pounds per acre dicamba applied in late fall just before the first frost.

On **non-cropland** apply picloram at 2 pounds per acre.

Quack Grass—To increase the effectiveness of the herbicide treatment, rotavate or disc thoroughly, and harrow in the spring or early summer. Within the next 5 days apply TCA at 20 to 40 pounds per acre in 80 to 100 gallons of water per acre. If root stocks are not completely killed, follow in 2 to 3 weeks with further tillage or another application of TCA. TCA may persist in the soil for one or more years.

Or, cultivate the quack grass in the spring, and apply dalapon at 15 to 20 pounds in 10 to 20 gallons of water per acre when the grass regrowth is 6 to 8 inches high. Follow in 2 to 3 weeks with tillage.

Small Patches on Non-Cropland—Apply atrazine in the spring at 2.5 to 3 ounces per 100 square feet; or bromacil in the spring at 0.5 to 0.75 ounces per 100 square feet or monuron in early spring or late fall at 2 ounces per 100 square feet. Normal development of crop plants will be prevented for two or more years by the other treatments. Do not cultivate after the application of monuron.

Dandelion—Dandelions spread from seed or from root segments which have been cut with farm machinery. The seeds will germinate whenever moisture conditions are favorable. Seedlings are easily killed by cultivation. The main difficulty is with old plants that survive cultivation and become re-established.

After harvest and summerfallow, tillage with cultivators must be deep enough to cut the plants below the crown. The discer is usually ineffective in well-established stands. If the soil is too wet for effective cultivation, use an ester of 2,4-D at 2 pounds per acre instead of tillage. After summerfallowing, seed wheat or barley, and spray with an ester of 2,4-D at 12 ounces per acre. Prevent seed production on nearby areas and avoid re-infestation by destroying new seedlings when they appear.

Wild Barley—This short-lived perennial has a fibrous root system. Use thorough tillage to destroy the old plants before seeding to cereal or forage crops. At present, no herbicide can be recommended to kill this weed without injury to other species.

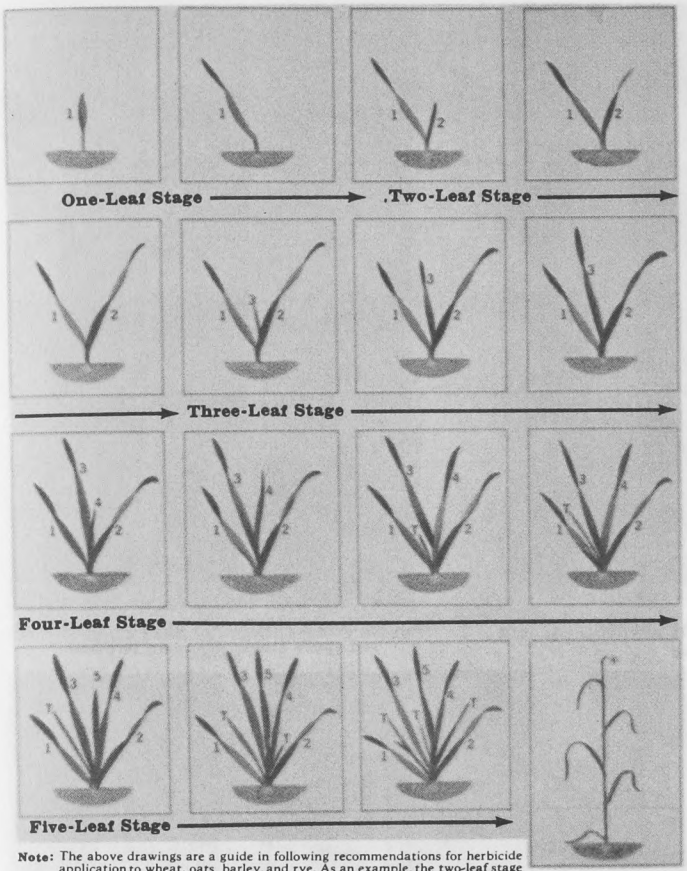
Povertyweed—This long-lived perennial has a very extensive root system. At least 2 years of intensive tillage are required to kill the roots. Summerfallow should be started with cultivation immediately after harvest. Seed to wheat or barley (use barley if infestation is on saline soils) and spray with 2,4-D at 12 ounces per acre. Delay application until povertyweed is fully emerged but spray before the early shot-blade stage.

As an alternative on saline soils, seed grasses such as tall wheat grass or slender wheat grass, which tolerate a higher salt content than most other grasses. Once the grass is well established, repeated applications of 2,4-D at 16 ounces per acre or 2,4-DB at 24 ounces per acre will keep down the topgrowth of povertyweed.

Absinth—This perennial weed spreads by seeds and shallow horizontal roots. It becomes established in uncultivated land and sometimes spreads into cultivated fields. It is objectionable because its strong penetrating odor may taint flour and milk.

Thorough tillage starting with after-harvest cultivation in the fall, followed by a season of summerfallow will control this weed. It cannot be controlled by herbicides in cereal crops. After-harvest cultivation will prevent new plants from becoming established. In grassland it can be controlled by repeated applications of 2,4-D at 1.5 pounds per acre in the spring and fall or dicamba at 8 ounces per acre applied when new growth is 4 to 10 inches tall.

Leafy Spurge, Toadflax, Russian Knapweed, Hoary Cress, Bladder Campion, and Field Bindweed—These persistent perennial weeds are a major threat to crop production and a determined effort should be made to eliminate them wherever they occur. Eradication of these weeds is difficult but they can be controlled. If any of these weeds are discovered, get detailed recommendations and information on assistance and control programs from your municipal secretary, agricultural representative, or the Weed Specialist, Plant Industry Division, Saskatchewan Department of Agriculture, Regina.



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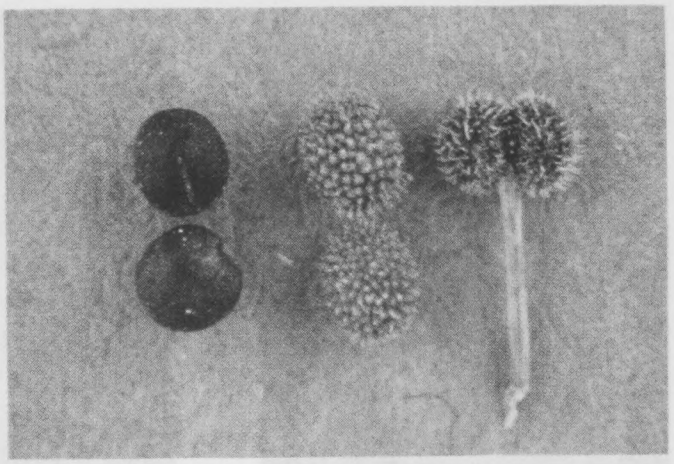

Fig. 3—left to right: rapeseed; cleavers seed; cleavers still attached to the pedicle

Fig. 2—Cleaver plant

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Saskatchewan Department of Agriculture

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Tillage must be frequent enough to prevent regrowth from appearing for more than 1 week. Shoots should be cut off 2 to 4 inches below the soil surface at every operation.

To preserve trash or if it is too wet to cultivate, 2,4-D or MCPA at 16 ounces per acre, or dicamba + 2,4-D + mecoprop mixture at 8 ounces per acre can be used instead of tillage during the summerfallow operations. Cultivate early in the season to destroy annual weeds and volunteer grain. Allow the thistles to reach the early bud stage before applying the herbicides. Cultivate again as soon as the thistles show signs of regrowth.

The following year, spray the thistles in the crop. In wheat and barley, apply an ester or amine of 2,4-D or MCPA at 8 to 12 ounces per acre. These rates of MCPA or 2,4-D may injure the grain. Delay the application until the maximum number of thistle shoots has emerged, but apply before the shot-blade stage of the grain.

Or, in wheat and oats, apply a dicamba + 2,4-D + mecoprop mixture at 8 ounces per acre at the three- to five-leaf stage of the crop. Regrowth in the stubble should be sprayed or cultivated shortly after harvest.

In cereals seeded down to alfalfa, red clover, or white clover, apply an ester of 2,4-DB at 24 ounces per acre from the four-leaf up to the shot-blade stage.

On non-cropland, apply 2,4-D at 2 pounds per acre, or dicamba + 2,4-D + mecoprop mixture at 2 pounds per acre, or dicamba alone at 1 pound per acre, or picloram (Tordon) at 0.5 to 1 pound per acre, when the thistles reach the bud stage. Use 30 to 50 gallons of water per acre or enough to completely cover the thistle plant. These treatments may injure but will not destroy grasses.

Nodding Thistle—Apply 2,4-D ester or amine at 16 ounces per acre in the spring (June) and again in the fall (September).

Field Bindweed, Hedge Bindweed—To increase the effectiveness of the herbicide treatment, start summerfallow tillage when the weeds emerge in the spring. Cultivate whenever regrowth is 1 to 3 inches long. About mid-July allow the bindweed to grow undisturbed until it reaches the early bud stage. Then apply an ester of 2,4-D at 12 to 16 ounces per acre. When regrowth occurs, resume cultivation and continue as required until freezeup. Plant wheat or barley the following spring and spray the bindweed in the crop with an ester of 2,4-D at 8 ounces per acre. Immediately after harvest cultivate or spray with 2,4-D at 12 to 16 ounces per acre. Repeat this rotation.

Small Patches—Two years of intensive cultivation will usually eliminate these weeds. Sodium chlorate or sodium borate, at 3 to 4 pounds per 100 square feet, or 2,3,6-TBA at 10 pounds per acre applied in the spring, or 2 to 4 pounds per acre dicamba applied in late fall just before the first frost.

On **non-cropland** apply picloram at 2 pounds per acre.

Quack Grass—To increase the effectiveness of the herbicide treatment, rotavate or disc thoroughly, and harrow in the spring or early summer. Within the next 5 days apply TCA at 20 to 40 pounds per acre in 80 to 100 gallons of water per acre. If root stocks are not completely killed, follow in 2 to 3 weeks with further tillage or another application of TCA. TCA may persist in the soil for one or more years.

Or, cultivate the quack grass in the spring, and apply dalapon at 15 to 20 pounds in 10 to 20 gallons of water per acre when the grass regrowth is 6 to 8 inches high. Follow in 2 to 3 weeks with tillage.

Small Patches on Non-Cropland—Apply atrazine in the spring at 2.5 to 3 ounces per 100 square feet; or bromacil in the spring at 0.5 to 0.75 ounces per 100 square feet or monuron in early spring or late fall at 2 ounces per 100 square feet. Normal development of crop plants will be prevented for two or more years by the other treatments. Do not cultivate after the application of monuron.

Dandelion—Dandelions spread from seed or from root segments which have been cut with farm machinery. The seeds will germinate whenever moisture conditions are favorable. Seedlings are easily killed by cultivation. The main difficulty is with old plants that survive cultivation and become re-established.

After harvest and summerfallow, tillage with cultivators must be deep enough to cut the plants below the crown. The discer is usually ineffective in well-established stands. If the soil is too wet for effective cultivation, use an ester of 2,4-D at 2 pounds per acre instead of tillage. After summerfallowing, seed wheat or barley, and spray with an ester of 2,4-D at 12 ounces per acre. Prevent seed production on nearby areas and avoid re-infestation by destroying new seedlings when they appear.

Wild Barley—This short-lived perennial has a fibrous root system. Use thorough tillage to destroy the old plants before seeding to cereal or forage crops. At present, no herbicide can be recommended to kill this weed without injury to other species.

Povertyweed—This long-lived perennial has a very extensive root system. At least 2 years of intensive tillage are required to kill the roots. Summerfallow should be started with cultivation immediately after harvest. Seed to wheat or barley (use barley if infestation is on saline soils) and spray with 2,4-D at 12 ounces per acre. Delay application until povertyweed is fully emerged but spray before the early shot-blade stage.

As an alternative on saline soils, seed grasses such as tall wheat grass or slender wheat grass, which tolerate a higher salt content than most other grasses. Once the grass is well established, repeated applications of 2,4-D at 16 ounces per acre or 2,4-DB at 24 ounces per acre will keep down the topgrowth of povertyweed.

Absinth—This perennial weed spreads by seeds and shallow horizontal roots. It becomes established in uncultivated land and sometimes spreads into cultivated fields. It is objectionable because its strong penetrating odor may taint flour and milk.

Thorough tillage starting with after-harvest cultivation in the fall, followed by a season of summerfallow will control this weed. It cannot be controlled by herbicides in cereal crops. After-harvest cultivation will prevent new plants from becoming established. In grassland it can be controlled by repeated applications of 2,4-D at 1.5 pounds per acre in the spring and fall or dicamba at 8 ounces per acre applied when new growth is 4 to 10 inches tall.

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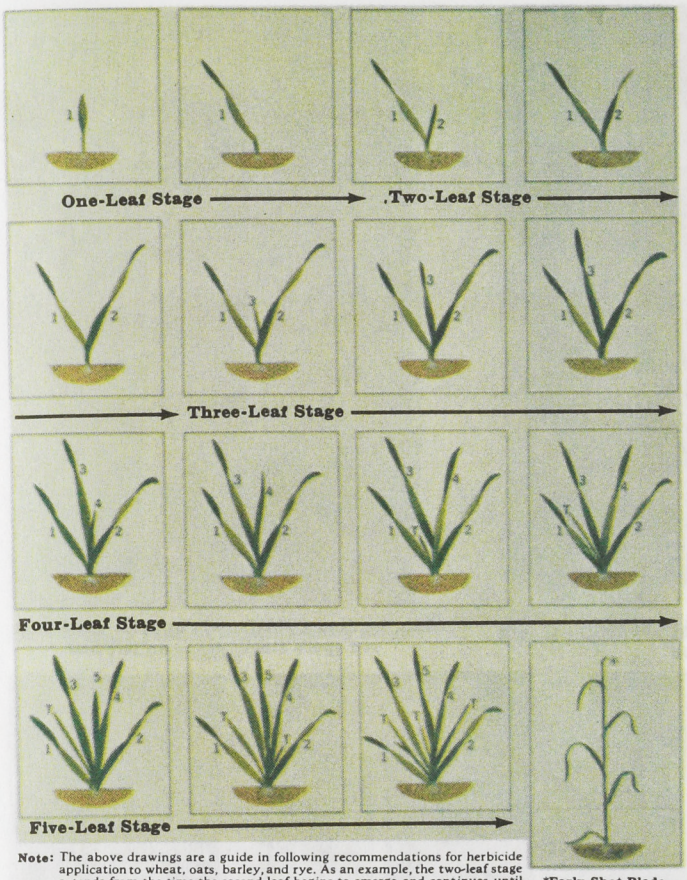

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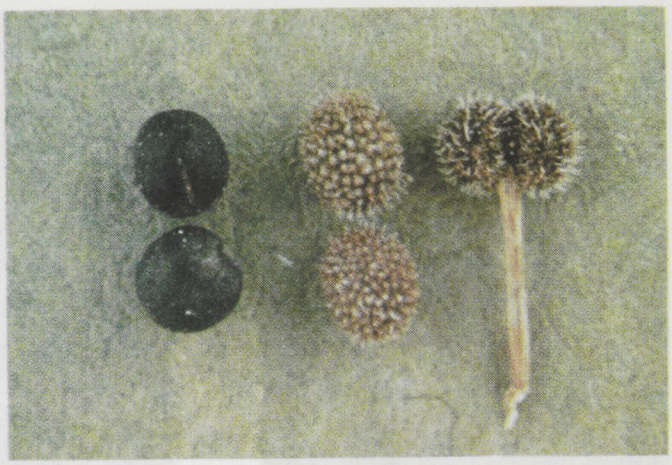

Fig. 3—left to right: rapeseed; cleavers seed; cleavers still attached to the pedicle

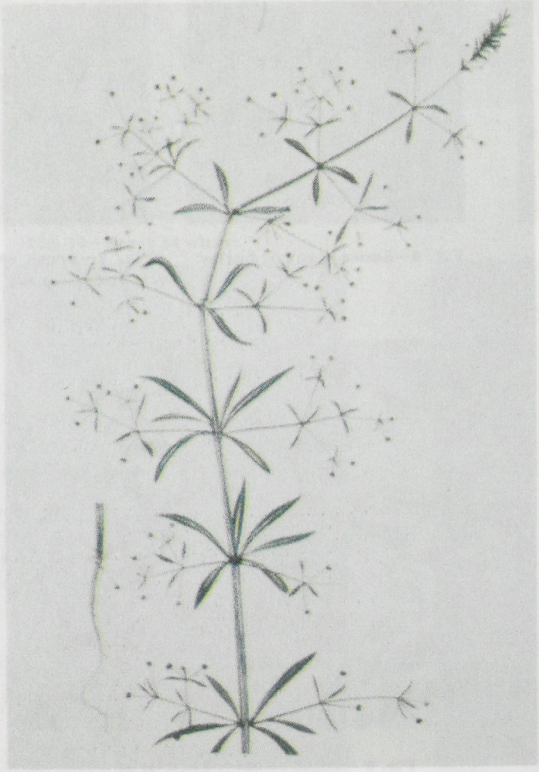

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Fig. 1—Stem rust of wheat

Fig. 2—Leaf rust of wheat

Fig. 3—Crown (leaf) rust of oats; black and red spore stages occur on left leaf

Fig. 4—Bunt of wheat; healthy kernels below

Fig. 5—Covered smut of barley; healthy at left

Fig. 6—Loose smut of barley

Fig. 7—Loose smut of slender wheat grass

Fig. 8—Loose smut of wheat; healthy at left

Fig. 9—Smut of oats; healthy at left

Fig. 10—Black point of wheat; healthy kernels above

Fig. 11—Common root rot of wheat; healthy at right

Fig. 12—Prematurity blight of wheat; healthy at right

Fig. 13—Ergot of wheat

Fig. 14—Ergot of barley

Fig. 15—Ergot of rye

Fig. 16—Ergot of bromegrass

Fig. 17—Ergot of wheatgrass

Fig. 18—Ergot of canary grass

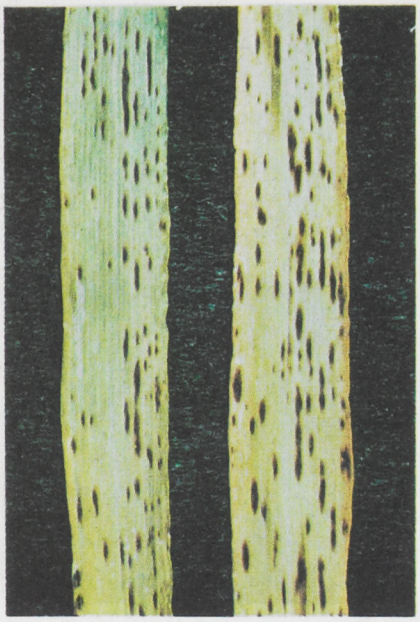


Fig. 19—Spot blotch of wheat

Fig. 20—Septoria leaf blotch of wheat

Fig. 21—Scald of barley

Fig. 22—Speckled (Septoria) leaf blotch of barley

Fig. 23—Net blotch of barley

Fig. 24—Bacterial leaf blight of barley

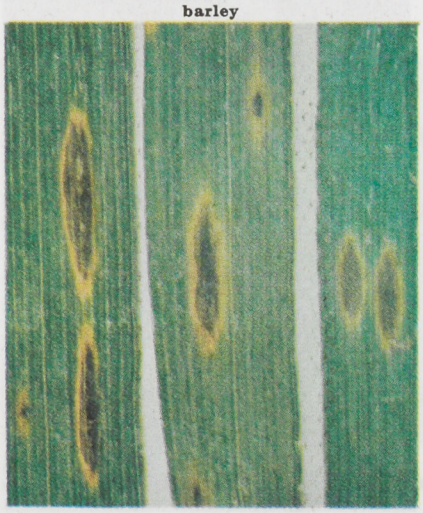


Fig. 25—Pyrenophora leaf spot of bromegrass

Fig. 26—Selenophoma leaf spot of bromegrass

Fig. 27—Septoria glume blotch of wheat

Fig. 28—Aster yellows of rapeseed

Fig. 29—White rust on leaf of rapeseed

Fig. 30—Sclerotinia stem rot of rapeseed

Fig. 31—Staghead (white rust) of rapeseed

Fig. 32—White rust lesion on stem of rapeseed

Fig. 33—White rust on flowers and pods of rapeseed

Fig. 34—Root rot of rapeseed

Fig. 35—Ringspot on stems of rapeseed

Fig. 36—Alternaria black spot on stems of rapeseed

Fig. 37—Yellow leaf blotch of alfalfa

Fig. 40—"LTB" snow mould of lawn grass

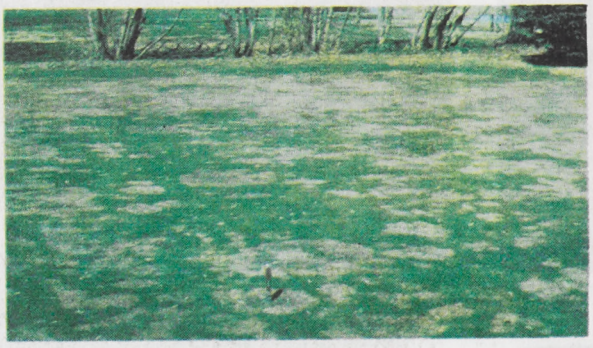


Fig. 41—"Fusarium" snow mould of lawn grass

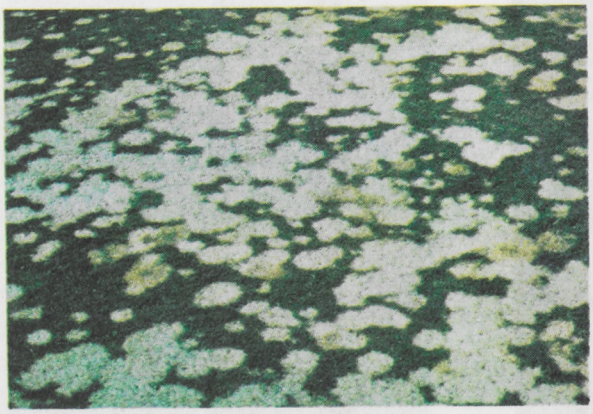


Fig. 42—"Sclerotinia" snow mould of bentgrass

Fig. 38—Winter injury to sweet clover

Fig. 43—Common scab of potato; healthy below

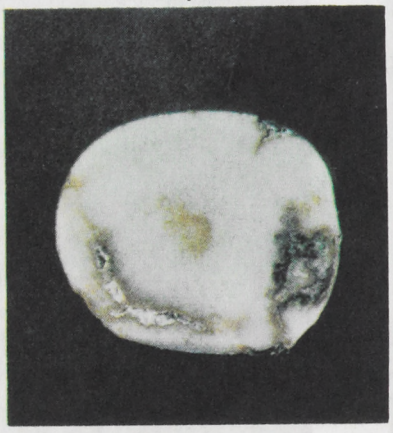


Fig. 44—Bacterial ring rot of potato

Fig. 39—Blackstem on alfalfa leaf

Fig. 45—Alternaria leaf spot of safflower

Fig. 46—Fire blight of crabapple

Fig. 1—left to right: Wireworm adult, full-grown larva, and pupa

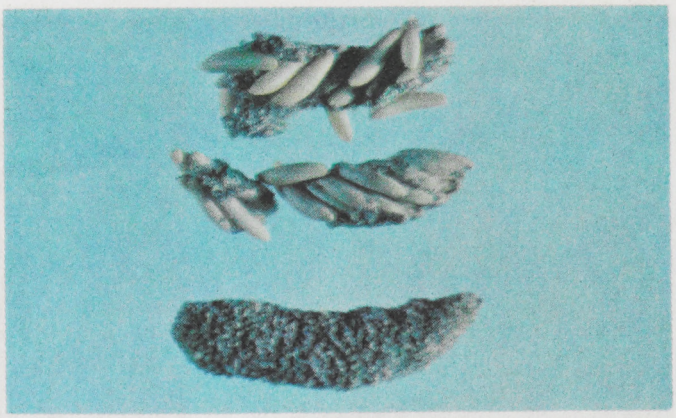


Fig. 3—Grasshopper eggs and egg pod

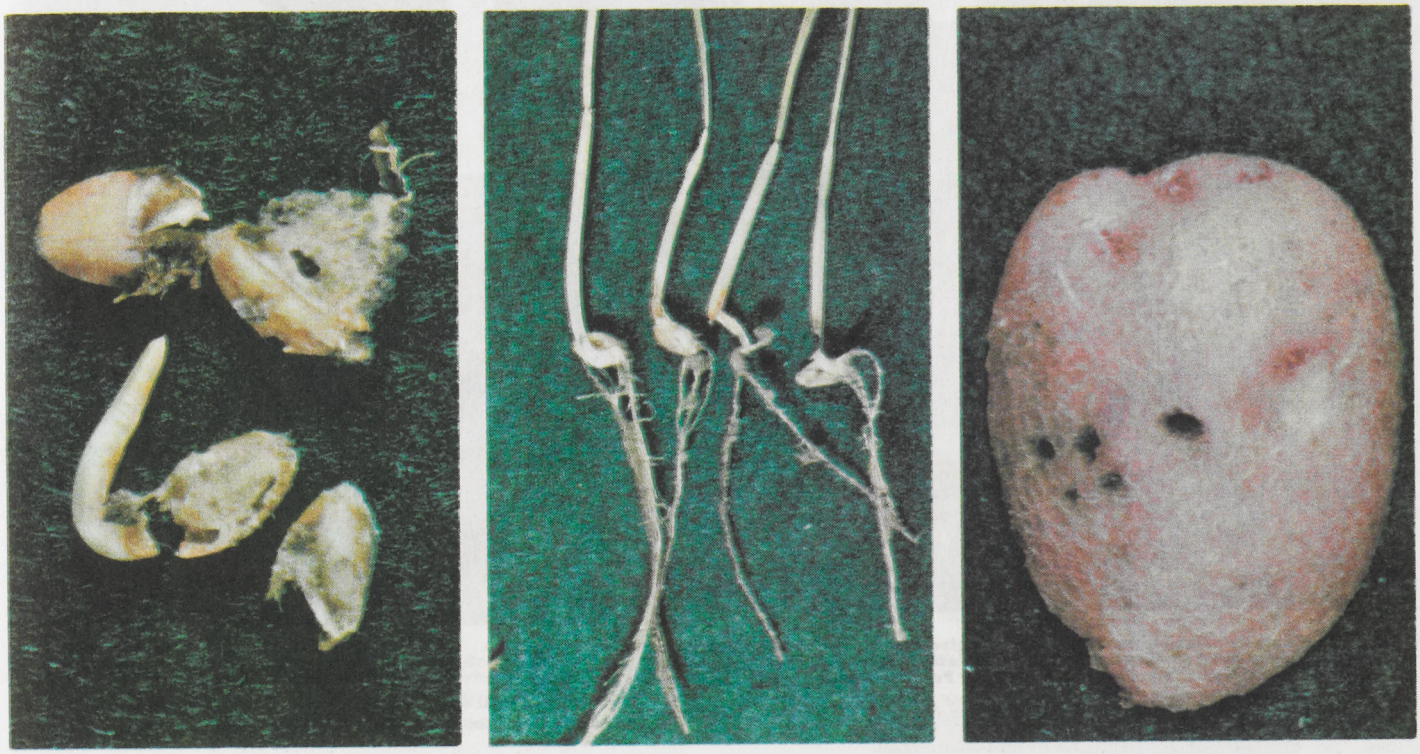


Fig. 2—left to right: Wireworm damage to wheat seed, wheat seedlings, and potatoes

Fig. 4—Flea beetles and their damage to seedling rapeseed

Fig. 5—Red turnip beetle on rapeseed

Fig. 6—Maturing beet webworms on a rapeseed leaf

Fig. 7—Bertha armyworm on rapeseed

Fig. 8—Diamondback moth larva on rapeseed

Fig. 1—Rapeseed, flax, or mustard residues give poor protection against erosion. Left: Water erosion on summerfallow after rapeseed; Right: Wind erosion on summerfallow after flax (Cropping Practices section, page 127)

Fig. 2—Press drill seeding (left) proper depth, discer seeding (right) same field, too deep (Cropping Practices section, page 129)

Typical Border Dyke System (Irrigation, page 84)

Wheel Move Sprinkler System (Irrigation, page 84)

Fig. 1—Creeping-rooted alfalfa (right) compared with common alfalfa (left). Rambler, Roamer, Drylander, and Kane are creeping-rooted varieties with good winterhardiness and persistence.

Fig. 2—Grass-alfalfa mixtures (left) outyield grass alone (right) especially as stands get old.

Fig. 3—In the Brown and dry parts of the Dark Brown soil zone, grass-alfalfa seeded in alternate rows 24 inches apart yields more than these crops mixed in the same row.

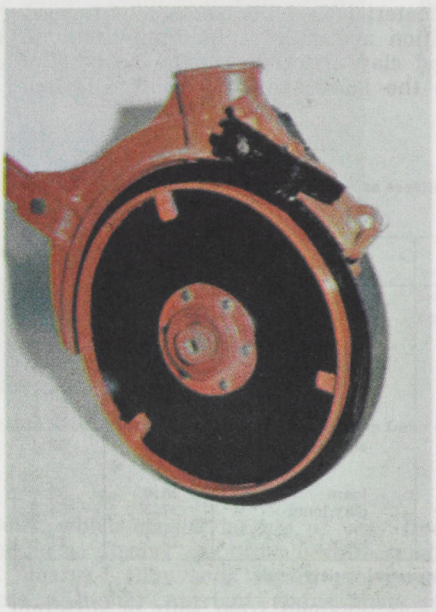


Fig. 4—A flange ring spot welded to drill disc for depth control

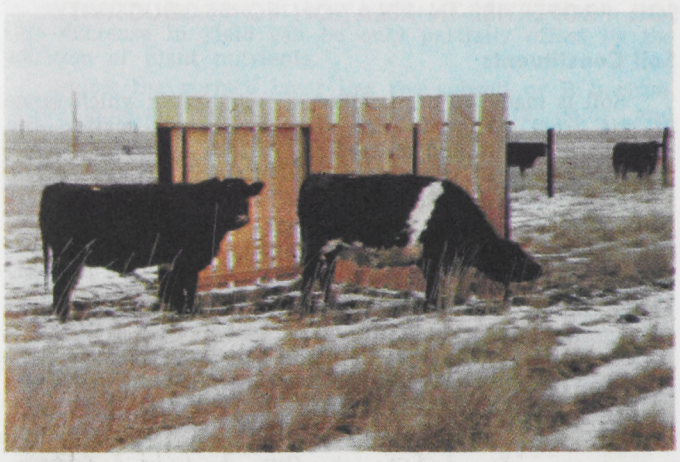


Fig. 5.—Russian wild ryegrass can be used to extend the grazing season into the fall and early winter.

Fig. 6—Close grazing reduces vigor of native prairie. Plants were treated left to right as follows: a. not clipped, b. clipped to 5-inch height, c. clipped to 3-inch height, d. clipped to 1½-inch height. The plants were clipped at 2-week intervals for 5 months and then removed from the soil.

SOILS AND FERTILIZERS

PRODUCTIVITY OF SASKATCHEWAN SOILS

The soils of Saskatchewan vary widely in their ability to produce crops. The major factors which affect the productivity of the soil are:

1. The broad climatic or soil zone in which the soils occur. (See Fig. 1.) The soil zones range from the arid Brown zone in Southwestern Saskatchewan through the Dark Brown to the less arid Black (Parkland) zone and the Gray (wooded) and the organic soils of the north; 2. the geological material on which the soil is formed (this varies in composition and may range from sandy to very sandy fine-textured clay material); 3. the position of the soil in relation to the landscape (i.e., knoll, midslope, or depression).

TABLE I

Effect of Soil Zone and Soil Texture on Yields of Fallow-Seeded Cereal Grains*
(Average Yields for the Period 1950-1969)

Soil Zone	Soil Texture	Grain Yields (bu/ac) Wheat	Barley	Oats
Brown	clay loam	22.1	32.5	54.6
	heavy clay	24.9	39.5	60.6
Dark Brown	loam	26.0	33.6	49.8
	clay	30.1	54.2	65.3
Black	loam	33.2	50.7	61.5
	heavy clay	41.3	62.5	82.8
Thick Black	silty clay loam	43.3	58.1	73.5
Gray-Black	loam	26.9	38.9	44.6
	clay loam	37.3	54.3	66.6
Gray	loam	29.5	41.6	56.4

*Data from cereal variety trials.

The yields obtained from soils of different texture in different soil zones are illustrated in Table I. Within any one soil zone, higher yields of wheat, barley, and oats are usually obtained on the heavier textured soils. The maximum yields of cereal grains are obtained on Thin Black and Thick Black soils. The data in Table I are from small plot investigations under good management. Therefore, these yields may be somewhat in excess of yields obtained under other management practices.

TABLE II

Yield of Wheat (Bu/ac) Within One Field
(Edenwold Area-1960)

Slope Position	Kind of Soil	Yield
Knoll	Calcareous	29.9
Upper slope	Orthic	49.8
Lower slope	Eluviated	39.0
Depression	Gleysol	24.5

TABLE III

Effect of Soil Zone and Available Nitrogen Level on Yields of Stubble-Seeded Wheat*
(Average Yields for the Period 1963-1969)

Soil Zones	Wheat Yields (bu/ac) Available Soil Nitrogen to 2 Ft Less Than 31 lb/ac	31-60 lb/ac	Greater Than 60 lb/ac
Brown	13.7	15.0	17.6
Dark Brown	17.9	19.4	23.2
Black and Thick Black	15.6	18.8	24.2
Gray-Black and Gray	11.5	18.0	16.2

*Data from field fertilizer trials—nonfertilized yields are reported.

Wide variations in the kind of soil profile may be found within local areas. Yields of wheat on these closely related soils (Table II) vary as widely as between similar textured soils separated by hundreds of miles. Part of the difference in yields reported for the different soil profiles in Table II is undoubtedly related to the different levels of moisture available for plant growth on the different slope positions.

The yields of stubble-seeded cereal grains are also affected by the soil zone in which the soils occur. (See Table III.) Yields of stubble-seeded wheat are generally greater in Black soils and the more moist parts of the Dark Brown soil zone. In addition, yields of stubble-seeded grains are markedly affected by the amount of available soil nitrogen. The data in Table III show that moisture is not the only factor limiting stubble yields in Saskatchewan.

TABLE IV

Potential Yields of Wheat (bu/ac)

Soil Zone	Fallow	Stubble
Brown	27	21
Dark Brown	41	33
Black	60	45
Gray-Black	52	41

The lack of available soil moisture is undoubtedly a major factor which limits the yields of crops in Saskatchewan. However, the level of production possible with the moisture available is much higher than is commonly recognized. The yield figures shown in Table IV represent the production that might be obtained if moisture were the only factor limiting yields. These and other research data concerning production suggest that a marked increase in the long-term average yields of cereal grains is feasible. An understanding of soils and the significance of their physical, chemical, and biological properties as they relate to crop production is the first step in achieving these potential yields.

SOIL PROPERTIES IN RELATION TO PRODUCTIVITY

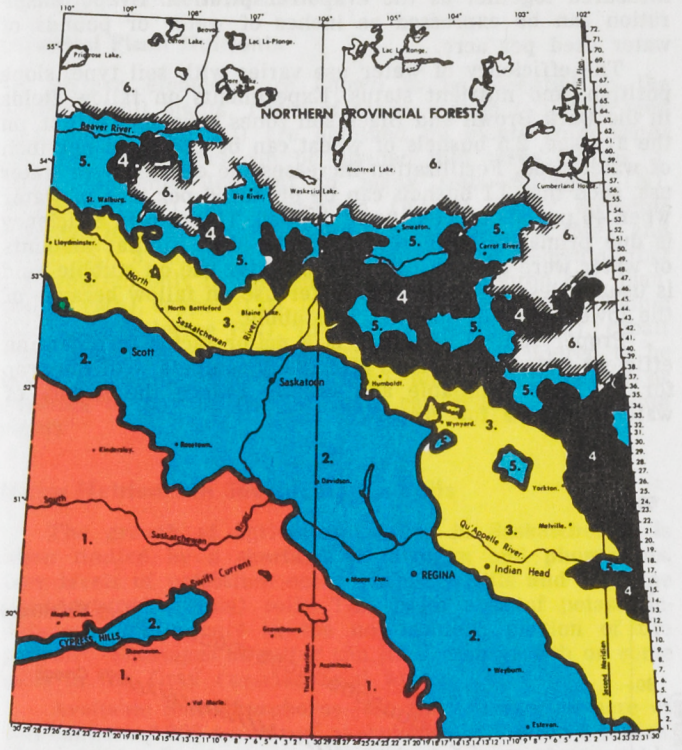
Soil Constituents

Soil is made up of: 1. **Mineral components** which range in size from stones to fine clay; 2. **organic matter**—the remains of plants and animals in various stages of decomposition; 3. **soil organisms**—the bacteria, fungi, algae, protozoa, and worms found in the soil; 4. **soil atmosphere** with nitrogen, oxygen, and carbon dioxide as the chief components; 5. **water**; 6. **plant nutrients** and other salts found in soil water and in the mineral and organic portions of the soil.

TABLE V

Removal of the Topsoil Reduces Yield
All treatments shown in Table V received a uniform application of N P K.

	Dryland			Irrigated
	Wheat	Oats Bu/ac	Barley	Tomatoes Tons/ac
With A horizon present	47.4	71.4	58.4	19.9
With A horizon removed	21.4	25.5	27.3	9.4
With A horizon removed plus 40 tons manure/acre	—	—	—	20.8



LEGEND:

1. Brown soils
2. Dark Brown soils
3. Thin Black soils
4. Thick Black and Gray—Black soils
5. Gray (wooded) soils
6. Gray soils and muskeg

Fig. 1—Major soil zones of Saskatchewan

The Soil Profile (See Fig. 2)

The proportions and arrangements of the constituents listed below vary with depth in the soil. As a result, a series of layers or horizons can be recognized in a vertical soil cut. The whole series of layers, from the surface downwards, is called the soil profile.

The upper part of the soil profile is referred to as the A horizon. This contains more organic matter, is darker in color, and is more fertile than underlying horizons. **Loss of the A horizon by erosion or by deliberate removal is followed by a serious decrease in crop yields.** Table V shows that this decrease in yield can be only partially offset by the addition of plant nutrients.

Below the surface layer lies the subsoil or B horizon, which generally exhibits a distinct structure, color, and composition. The properties of the B horizon have a pronounced effect on crop growth. The very hard B horizons of Solonetzic soils can severely retard root and water penetration.

The C horizon, or the geological deposit lying below the B, is the parent material of the soil. Similar material once existed at the surface but, as a result of the process of soil formation, it has been transformed into the present A and B horizons. Many properties of the parent material such as texture, lime content, and salt content exert a strong influence on the type of soil formed and its productivity.

Soil Texture

The ease with which a soil can be worked depends to a large extent on the size of the soil particles; that is, on the soil texture. Soil particles can be classified into **sand, silt,** and **clay,** depending on their size. The sand particles are relatively large, while the clay particles, less than 1/10,000 of an inch in diameter, can be seen only with a powerful microscope. Varying amounts of sand, silt, and clay result in soils being separated into different classes of texture such as sand, sandy loam, loam, clay loam, silty clay loam, and clay.

Fig. 2—An Orthic Black profile occurring in the Blaine Lake area, showing the soil horizons

Clay soils, which consist largely of very fine particles, are referred to as "heavy" or "fine," while sandy soils are "light" or "coarse." Clay soils retain more moisture and usually have a higher nutrient status than sandy soils. Except for very wet years, the finer textured clay soils are the most desirable for the production of cereal crops in Saskatchewan.

Organic Matter

Soil organic matter consists of plant and animal remains in various stages of decay, living and dead soil organisms, and materials synthesized by the organisms. The term **"humus"** refers to the residue left after the initial decay of fresh organic materials. The surface color of the soil reflects the humus content. Organic matter and clay serve as the major storehouses for plant nutrients and water, and they are the most important factors affecting soil tilth or structure.

The organic matter content of Saskatchewan soils varies with the soil zone. The content increases from the Brown to the Black zones and decreases again from the Black to the Gray zones. Much of this organic material is relatively old, with average ages ranging from 200 to 1,000 years. This older material, in a practical sense, is "stable" and not subject to further decay. A small nitrogen-rich "active portion" is of utmost importance to soil fertility.

Soil Organisms

In addition to plant roots, life in the soil includes many types of organisms. The live weight of these organisms is often as high as that of the crop grown on the soil. Soil

organisms are responsible for decomposing the organic materials added to the soil and consequently releasing plant nutrients tied up in the crop residues. The activity of these organisms has a profound effect on soil productivity. They control the availability of nitrogen and of the micronutrients or trace elements. In addition, certain by-products of their activity, such as gums, hold soil particles together. The proper incorporation of crop residues into the soil will maintain an adequate level of "active" organic matter, promote favorable soil structure, and in the long run result in high yields.

Soil Structure and Aeration

The importance of soil structure in crop production is often underestimated. If structure is poor, yields may be low even though all other factors are optimal.

The term "soil structure" indicates the arrangement of soil particles and the aggregation of small particles to form large ones. Soils with good surface structure have a cloddy or granular surface which does not break down during a rain or wind storm. In contrast, sandy soils or those without aggregation are poorly structured. Medium- and fine-textured soils with poor structure tend to crust and bake. Surface crusting may cause poor aeration and restrict plant emergence. Crop residues protect the surface of the soil, increase the infiltration rate, and reduce runoff. They also aid in the formation of a stable crumb or cloddy surface structure, further promoting infiltration.

Structure and the distribution of pores in the soil are closely associated. The larger pores will readily drain after a rain and are important in providing adequate aeration of the soil; the smaller pores will retain water and contribute to the soil's moisture-holding capacity. A proper balance of large and small pores is a characteristic of well-structured soils; for example, the volume of air-filled pores should not drop below 20 percent for long periods. Good surface structure, which may be maintained by the retention of all crop residues, makes a soil less susceptible to wind and water erosion. Poorly structured soils and eroded soils require soil-improving crops such as legumes or grasses.

Soil Water

A shortage of water is often the factor limiting crop yields in Saskatchewan. The water available to plants includes rainfall during the growing season, and part of the moisture stored in the soil at seeding time. May to September rainfall ranges from about 7 to 12 inches. (See The Agricultural Climate of Saskatchewan, Fig. 2.) Not all the moisture stored in the soil at seeding can be extracted by the plant roots; water in soils can, therefore, be classified as available and non-available for plants.

Extraction of water from the soil by plant roots stops before the soil is completely dry. When this happens, the plants wilt and the soil has reached the **wilting point.** On the other hand, when a soil is saturated by a heavy rainfall or irrigation, part of the water may drain below the rooting depth and thus be lost to the plants. This downward movement of the water usually stops after a few days, and the amount of water then held by the soil is known as the **field capacity.** Plants can use only the water held between field capacity and wilting point and this water is called **available soil water.** The moisture content at the wilting point is closely related to texture and organic matter content; to a lesser degree the same is true for field capacity.

Crop Use of Water (Evapotranspiration)

The amount of water used to grow a crop can be calculated from rainfall records and from measurements of soil moisture in the spring and fall. The amount used consists of water transpired by the plant and that evaporated from the soil surface. Since these cannot be separated, they are measured together as the **evapotranspiration.** Evapotranspiration can be expressed as inches of water or pounds of water used per acre.

The efficiency of water use varies with soil type, slope position, and nutrient status. Experiments on fallow fields in the Dark Brown and Black soil zones have shown that, on the average, 2.5 bushels of wheat can be produced per inch of water used. Fertilization increases the efficiency of water use, such that 3.1 bushels can be produced per inch of water when 40 pounds of 11-48-0 are applied. The gain in efficiency is due primarily to increased yields, since similar amounts of water were used in both cases. Water use on stubble land is usually less efficient than water use on fallow because of the lower nutrient supplies in stubble.

Proper control of weeds is a major factor in obtaining efficient water use. Weeds effectively compete with the crop for the water available and greatly reduce the supply of water available for crops.

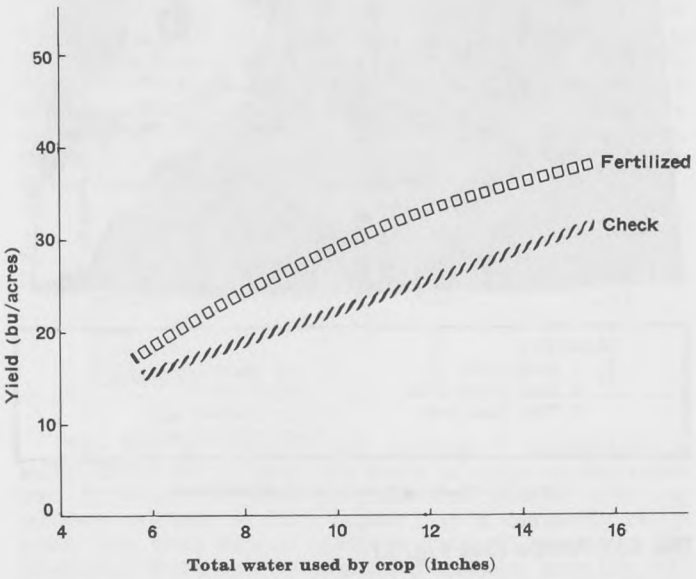


Fig. 3—Relationship between water use and wheat yield on stubble and fallow fields in the Dark Brown and Black soil zones (data from 1960 to 1967); Fertilized 11-48-0 at 40 pounds per acre on fallow; 28-23-0 at 80 pounds per acre on stubble

Fig. 3 shows the relationship between yield and water use for wheat grown in the Dark Brown and Black soil zones under present management practices. From 7 to 11 inches of water are needed to grow a 20-bushel-per-acre crop. Two to three inches of water must be stored in the soil in the Dark Brown and Black zones at seeding time to ensure a satisfactory crop with average precipitation. Three to four inches of water must be stored in the Brown soils at seeding time. The amount of available water stored in the soil can be estimated from the depth of moist soil. (See Table I of Cropping Practices section.)

Summerfallowing can be used to increase the supply of moisture stored in the soil. However, only a small portion of precipitation received during the fallow period can be stored. Past studies have shown that much of the moisture in summerfallow fields is stored in the first winter. Summerfallowing for moisture conservation could be unnecessary in many years, especially in the Black, Gray-Black, and Gray soil zones.

Summerfallowing sandy soils is a questionable practice, since they store only small amounts of water and are subject to wind erosion. However, soils which are sandy on the surface but have heavier textured subsoils may store sufficient water to make summerfallowing a useful practice. In addition, summerfallowing may be required for other purposes, such as weed control, increasing fertility, or providing a more stable production pattern.

PLANT NUTRIENTS IN SOILS

Essential Plant Nutrients

Sixteen elements are known to be essential to the growth of all plants. Three of these, carbon (C), hydrogen (H), and oxygen (O) are obtained by plants from water and air. The others can be divided into three classes: 1. **Major elements deficient in many soils**—nitrogen (N), phosphorus (P), and potassium (K); 2. **major elements deficient in some soils**—calcium (Ca), magnesium (Mg), and sulfur (S); 3. micro-nutrient elements (trace elements) that are required only in very small quantities—boron (B), manganese (Mn), copper (Cu), iron (Fe), zinc (Zn), molybdenum (Mo), and chlorine (Cl). In addition, sodium (Na), cobalt (Co), vanadium (V), and silicon (Si) are considered to be essential to the growth of some plants. Deficiencies or excesses of any of the nutrients can reduce growth and yields.

Major Nutrients in Saskatchewan Soils

The growth of agricultural crops in Saskatchewan is often limited by a shortage of nitrogen and phosphorus. Low levels of potassium occur on peaty soils and on some light-textured (sandy) soils. The major area of potassium-deficient soils occurs in the northeastern portion of the province. Shortages of sulfur can limit crop growth on some soils in the Gray (wooded) soil zone.

Available Soil Phosphorus—On the average, an acre of soil contains 1,000 pounds of phosphorus in the top 6 inches. Most of this phosphorus is present in forms slowly available or completely unavailable to plants. Over 80 percent of Saskatchewan soils contain low levels of available phosphorus. Soil tests will determine the level of available phosphorus and will provide an estimate of the yield increases that can be expected from the application of various rates of fertilizer phosphorus.

Available Soil Nitrogen—The total nitrogen content in the top 6 inches of the surface soil of Saskatchewan can vary from 2,000 to 10,000 pounds per acre. Only a small portion of this total nitrogen is available in any one year for crop growth. The available nitrogen in the soil can vary greatly from year to year. A specific field may contain abundant available nitrogen one year and be severely deficient the next. Micro-organisms in the soil control the release of nitrogen from the organic matter (humus) to a form which is available to plants. During the summerfallow period, nitrogen is released from crop residues and dead microbial cells. Therefore, on summerfallow fields the amount of available nitrogen is usually adequate for crop growth. However, the amount of nitrogen available to plants growing on stubble fields is frequently in short supply. Table VI shows average levels of available nitrogen on summerfallow and stubble across the entire province. Fig. 4 shows the average levels of available soil nitrogen of stubble and summerfallow fields in the various soil zones of the province for the period 1966 to 1969. The Thick Black soils, with their high organic matter content, normally have much higher levels of available soil nitrogen than soils of other zones.

TABLE VI

Available Soil Nitrogen Levels in Saskatchewan Soil Pounds of Nitrate Nitrogen Per Ac to a Depth of 2 Ft*

For Crops Seeded	Summerfallow	Stubble
1967	76	33
1968	71	51
1969	63	40

*Average data obtained from soil test summaries.

It is important to remember that the data given in Table VI and Fig. 4 are averages for a number of fields. **Wide variations in available nitrogen levels occur between individual fields.** Soil testing is the most reliable method of determining the available nitrogen level of a specific field, and provides the best information for determining fertilizer use on a particular field.

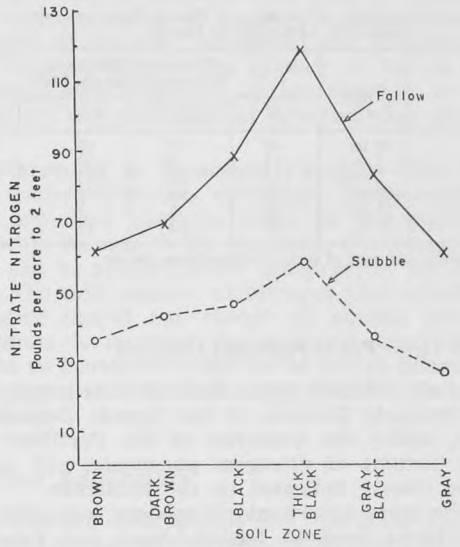


Fig. 4—Nitrogen levels of stubble and fallow fields—from soil test summaries in Saskatchewan. 1966-1969

Available Soil Potassium—Potassium is available in sufficient quantities to satisfy crop growth in most Saskatchewan soils. The total amount of potassium often exceeds 20,000 pounds per acre in the top 6 inches. Available levels of potassium generally range between 300 and 2,000 pounds per acre. However, some soils have as little as 30 pounds per acre of available potassium, and a minimum of 120 pounds per acre of available potassium is required for the good growth of cereal grains. The main areas of potassium-deficient soils occur in Northeastern Saskatchewan. The need for potash fertilization can be determined by a soil test.

Plant Nutrient Deficiency Symptoms

Deficiencies of plant nutrients may be reflected in discoloration, stunted growth, or delayed maturity. A general yellowish color may indicate nitrogen deficiency. Nitrogen-starved plants are frequently seen on stubble land, in depressions, or on eroded soils. On stubble fields, further evidence for nitrogen deficiency is provided if the crop growing in the straw swath rows from the previous year has a more distinct yellowish color than the remainder of the field.

Phosphorus is the nutrient most often deficient in Saskatchewan soils yet severe visual deficiency symptoms are seldom evident in cereal grains. Severe phosphorus deficiencies may result in plants with a pale grayish-green color which changes to purple on older plant parts. Lack of potassium results in a browning or scorching of the tips and outer edges of the leaves.

Nutrient-deficiency symptoms as shown by plant colorations are very complex and are easily confused with other problems such as drought or disease.

Removal of Nutrients by Common Crops

Table VII shows the approximate quantities of nitrogen, phosphate, potash, and sulfur contained in various crops. To maintain soil fertility, at least as much plant food must be returned to the soil as is removed by harvesting a crop.

A ton of wheat straw, in terms of the nitrogen and phosphorus contained in it, is worth approximately $2.50. While the straw contains significant quantities of other plant nutrients, it is also beneficial in improving soil tilth, reducing

erosion damage, and increasing the water-holding capacity. Returning straw to the soil is strongly recommended but calculating the value of the complex benefits is very difficult.

TABLE VII

Nitrogen, Phosphate, Potash, and Sulfur Removed by Common Agricultural Crops

Crop	Yield Per Ac	Pounds of Nutrients Removed from the Soil			
		N	P_2O_5	K_2O	S
Wheat grain	30 bu	40	15	10	3
Wheat straw	1 ton	15	5	30	5
Alfalfa*	3 tons	135	30	135	15
Potato tubers	400 bu	80	30	150	6
Flaxseed	12 bu	26	8	7	11
Rapeseed	25 bu	60	20	15	5

*Legumes normally get part of their nitrogen from the air.

Fertilizers and Their Plant Nutrient Content

The sale of all fertilizer materials in Canada is regulated by the Plant Products Division of the Canada Department of Agriculture, under the authority of the Fertilizer Act. The minimum content of nitrogen, phosphate, and potash must always be clearly indicated on the container.

Some of the more important phosphorus, nitrogen, and potassium fertilizers used in Saskatchewan are listed in Table VIII. Some of the fertilizers listed also contain varying amounts of sulfur. This table is by no means complete and fertilizers containing other combinations of plant nutrients are available.

TABLE VIII

Partial List of Fertilizers

	Analysis	Percentage			
		Nitrogen N	Phosphate P_2O_5	Potash K_2O	Sulfur S
Nitrogen Fertilizers					
Urea	46–0–0	46	0	0	—
Urea	45–0–0	45	0	0	—
Ammonium Nitrate (Granular)	34–0–0	34	0	0	—
Ammonium Sulfate-Urea	34–0–0	34	0	0	11
Ammonium Sulfate	21–0–0	21	0	0	24
Anhydrous Ammonia	82–0–0	82	0	0	—
Nitrogen Solution	28–0–0	28	0	0	0
Phosphate Fertilizers					
Mono-Ammonium Phosphate	11–48–0	11	48	0	—
Mono-Ammonium Phosphate	11–55–0	11	55	0	—
Mono-Diammonium Phosphate	16–48–0	16	48	0	—
Diammonium Phosphate	18–46–0	18	46	0	—
Nitrogen Phosphates					
Ammonium Nitrate Phosphate	17–34–0	17	34	0	—
Ammonium Nitrate Phosphate	22–33–0	22	33	0	—
Ammonium Phosphate Sulfate	16–20–0	16	20	0	14
Ammonium Nitrate Phosphate	23–23–0	23	23	0	—
Ammonium Nitrate Phosphate	26–13–0	26	13	0	—
Ammonium Nitrate Phosphate	27–14–0	27	14	0	—
Ammonium Nitrate Phosphate	28–14–0	28	14	0	—
Potash Fertilizer					
Potash	0–0–60	0	0	60	—

Farm Manure—Farm manure is an excellent amendment for soil improvement. It is a valuable complete fertilizer containing all essential plant nutrients. On the average, cattle manure contains 10 pounds of nitrogen, 5 pounds of phosphate, and 10 pounds of potash per ton. Chicken or hog manure may contain up to five times as much nitrogen and phosphorus and ten times as much total salt as cattle or horse manure.

To avoid possible pollution, the indiscriminate use of manure without proper incorporation into the soil should be avoided. Regulations regarding manure disposal are now being prepared and these regulations should be studied before applying large quantities of manure to the land.

The greatest benefits from manure will result on saline soils, eroded soils, knolls and ridges, and the grayish-colored soils of upland depressions (depression or bluff podzol soils). Manure is best applied directly from the barn or feedlot on land that is to be fallowed. Ten tons per acre are sufficient, except on saline areas, where substantially higher amounts can be used. This is approximately equal to 25 cubic yards per acre. For chicken or hog manure rates of application should be reduced by a factor of five.

Other Fertilizer Materials and Soil Amendments

In addition to the materials mentioned, there are on the market many other forms of fertilizer materials and so-called soil amendments. Although some of these products have agricultural value, many are overpriced and of questionable value. Before investing money in products which have not been recommended, it would be wise to consider the following points:

1. If you decide to try the product, buy just enough to treat a small test plot. (Compare results with an adjoining plot in the same field on which the product is not used but on which all other operations and conditions are identical.)
2. Carefully evaluate all new products. Demand adequate proof of their value under your own conditions of operation.

Before You Invest—Investigate, After All It's Your Money.

FERTILIZER PRACTICES IN SASKATCHEWAN

The soils of the province are among the most fertile in the world. Of the chemical plant nutrients known to be required for the healthy growth of plants, only one—phosphorus—is in short supply in most soils. Nitrogen is seldom deficient on fallow land, but lack of it frequently limits the growth of agricultural crops seeded on stubble land and it is usually in short supply on tame hay or pasture not containing legumes. Potassium deficiency can occur on peaty soils and on some sandy soils. Sulfur fertilization is required for some crops grown in the Gray (wooded) soil zone.

Selection of Commercial Fertilizers

Fertilizers should be purchased after considering the guaranteed analysis which tells the quantity and kind of nutrients present. The cost of a fertilizer should, in general, be related to its content of plant nutrients. For example, if phosphorus is being purchased for use with cereal crops on summerfallowed land, a fertilizer carrying 10 percent phosphorus should cost only half as much as one containing 20 percent. If a nitrogen fertilizer is being purchased, 21-0-0 should cost only two-thirds as much as 33.5-0-0. **The cost of the fertilizer should be calculated in terms of the content of the plant nutrients needed for the crop.**

Calculation of Fertilizer Rates—Fertilizers have been labelled according to their guaranteed analysis in terms of nitrogen (N), phosphate (P_2O_5), and potash (K_2O). For example, 100 pounds of 11-48-0 contain 11 pounds of N, 48 pounds of P_2O_5, and 0 pounds of K_2O.

To calculate the rate of fertilizer required to supply a particular nutrient: Multiply the rate of the nutrient desired by 100 and divide by the percent of the nutrient present in the fertilizer.

For example:

1. If 20 pounds per acre of phosphate (P_2O_5) are to be used for a summerfallow seeded crop, the rate of 11-48-0 required can be calculated as follows:

$$\frac{20 \times 100}{48} = 42 \text{ pounds per acre}$$

42 pounds per acre of 11-48-0 would also supply

$$\frac{11 \times 42}{100} = 4.6 \text{ pounds per acre of nitrogen}$$

2. If 20 pounds per acre of phosphate (P_2O_5) and 40 pounds per acre of nitrogen (N) are to be used for a crop

to be seeded on stubble, the rates of fertilizer materials required can be calculated by:

a. the rate of phosphate (P_2O_5) desired is 20 pounds per acre and using 11-48-0, the calculation in Example 1 shows 42 pounds per acre are required. This application also supplies approximately 5 pounds per acre of nitrogen (N);
b. the rate of nitrogen (N) to be applied is 40 pounds per acre. Since 5 pounds per acre will be applied with the 11-48-0, the additional amount required is 35 pounds per acre (40-5). Using 34-0-0, the rate of fertilizer material will be:

$$\frac{35 \times 100}{34} = 103 \text{ pounds per acre}$$

Methods of Fertilizer Application

Fertilizer placement is at least as important as selecting the correct kind and amount of fertilizer. Proper application involves placing the right kind and amount of fertilizer where it will be readily available to the growing plant when it is needed, and in such a manner that germination injuries will not occur. No single method is best for all crops.

Placement of Phosphorus Fertilizers—As phosphorus stays within a few inches of its point of placement in the soil, it should be applied where the plant roots will intercept the fertilizer. For maximum yield increases, cereal grains should have 80 percent of their total phosphorus requirements met before they reach an age of 6 weeks. Therefore, all phosphorus carriers should be placed in close proximity to the seed so the phosphorus will be readily accessible to roots. It is important that phosphorus carriers be applied with a proper attachment mounted on the seeding unit. (See Agricultural Engineering section.)

Due to the very restricted movement of phosphrous in soil, surface-broadcast applications are much less efficient than seed placement of the fertilizer for cereal grains. In special areas such as eroded knolls, a broadcast application of a heavy rate of phosphate fertilizer, well mixed into the soil can be used. The results of such an application will increase the level of available phosphorus in the soil and the benefits may last for several years.

Placement of Nitrogen Phosphate Fertilizers—Although all phosphorus fertilizers should be applied with the seed of cereal grains, carriers such as 16-20-0, 23-23-0, and 26-13-0 may cause germination damage if applied with the seed at rates which supply more than 25 pounds of nitrogen per acre. In some cases, if adequate moisture is present it may be possible to exceed the suggested maximum rate of application with the seed without causing significant germination damage if the nitrogen compound in the fertilizer is ammonium nitrate. However, for fertilizers containing urea the suggested rate of 25 pounds of nitrogen per acre applied with the seed should not be exceeded. Refer to the section, Special Fertilizer Practices, for amounts of nutrients which can be placed with the seed for other crops.

Placement of Nitrogen Carriers—There are numerous forms of nitrogen fertilizers available. Forms which differ rather widely require somewhat different placement procedures. In contrast to the phosphorus carriers, a preseeding broadcast application is recommended for higher rates of nitrogen. The dry materials—34-0-0, 21-0-0, 45-0-0, and 46-0-0—can be broadcast in the fall or before tillage in the spring. It is not yet known whether significant losses to the atmosphere occur when the fertilizer is not incorporated into the soil; research information is incomplete. However, incorporation into the soil will **insure** that there will be no loss of nitrogen to the atmosphere. Other carriers such as nitrogen solutions (28-0-0) and anhydrous ammonia (82-0-0) may be applied in the fall or in the spring prior to seeding. Anhydrous ammonia should be applied at least 6 days prior to seeding.

Nitrogen fertilizers are rapidly transformed into nitrates by the nitrifying bacteria in the soil. In this form, the nitrogen moves freely with the soil moisture. This is why broadcast applications have proven quite satisfactory when moisture is adequate. However, where nitrogen is required in only moderate amounts (less than 25 pounds per acre) a seed-row application of a nitrogen phosphate fertilizer will probably be the most convenient and economical method.

Nitrogen required for grasses on hay or pasture fields is almost always applied by broadcasting, as incorporation in the soil by cultivation or injection may damage the crop stand.

Placement of Potassium Carriers—Most Saskatchewan soils contain adequate potassium. Crop responses to potassium are most likely to occur on the sandy soils in the northeast section of the province. For cereal grains, potassium can be applied either broadcast or drilled in with the seed. The total amount of nitrogen plus potash applied with the seed should not exceed 30 pounds per acre. Where potassium is required for rapeseed, mustard, and flax, it should be broadcast in the fall or before tillage in the spring. Potassium required for grasses and legumes should be broadcast.

Fertilizer Applicators

Fertilizer attachments are available for all types of seeding equipment through local implement dealers or fertilizer agents. They are easily attached and do not interfere with the normal operation of the equipment. Broadcast applicators for nitrogen fertilizers are available. Before buying a broadcast unit, ensure that it can distribute the fertilizer uniformly across the width of application.

Phosphorus and nitrogen carriers should not be applied by mixing with the grain in the seed box. This practice will damage the seeding mechanism and will also result in a very uneven seeding of both the grain and the fertilizer. Further information on fertilizer applicators can be obtained on page 15.)

Guidelines for Fertilizer Use

Recommended fertilizer practices are approved and periodically published by the Saskatchewan Advisory Fertilizer Council under the authority of the Minister of Agriculture for Saskatchewan.

For information on the most recent recommendations or for any changes, consult any of the following:

1. Agricultural representatives;
2. Canada Department of Agriculture research stations or experimental farm;
3. Saskatchewan Department of Agriculture;
4. Department of Soil Science, University of Saskatchewan, Saskatoon;
5. fertilizer agronomists.

Table IX supplies guidelines for nitrogen and phosphate application for cereal grains and grasses. For specific recommendations on the amount of nutrients to apply, have your soil tested.

TABLE IX

Guidelines for Fertilizer Application for Grains and Grasses

	Cereal Crops		Grasses	Legumes
Soil Zones	Phosphate on Fallow and Stubble* P_2O_5 lb/ac	Nitrogen on Stubble N lb/ac	Nitrogen for Hay, Pasture, and Seed Production** N lb/ac	P_2O_5 lb/ac
Brown	15–20	0–30	30–70	20–30
Dark Brown and Black	20–30	15–40	30–70	20–30
Thick Black, Gray-Black, and Gray	20–30	15–50	30–90	30–40

*The recommended phosphorus fertilizers contain a small amount of nitrogen.
**Use the lower rates under dry conditions.

Leave a Check Strip—The only way to assess the effect of a fertilizer is to leave an unfertilized (check) strip in the field. The check strip must be harvested separately to compare its yield with that of an adjacent equivalent area of fertilized crop in the same field. An adjacent unfertilized field is not a suitable check.

The soil will not be harmed by the use of registered fertilizers that comply with the requirements of the Fertilizer Act. If properly used they will rarely, if ever, cause burning of a crop in a dry season. The earlier, more rapid ripening brought about by phosphorus fertilizer should not be confused with burning.

Phosphorus for Fallow Cereal Crops—No agronomic practice has been investigated more thoroughly than the use of fertilizers for fallow-seeded cereal grains. These studies have shown:

1. Of the numerous forms of phosphorus fertilizer tested, the mono-ammonium phosphate (11-48-0 or 11-55-0) is the best.

2. The provincial average increase in yield for a 40-pound application of 11-48-0 is approximately 5 bushels per acre with the occasional increase up to 15 bushels per acre. The most profitable rate of application can be determined on the basis of a soil test.

3. Variation in yield from phosphorus fertilization can be expected from year to year. The examples given in Fig. 5 were obtained from field tests on Sceptre soils in the years 1950-67. Other soils show a similar pattern.

4. Optimum economic rates of application for different soils range from 30 to 80 pounds of 11-48-0 per acre. Crops use from 10 percent to 40 percent of the applied fertilizer phosphorus. The rest is held in the soil in a potentially available form. Thus, continued application of phosphorus may result in an increase in available soil phosphorus.

5. The placement of 11-48-0 with the seed is essential for maximum increases in yield.

6. The use of 11-48-0 results in up to 7 days earlier maturity in wheat, and up to 14 days in barley.

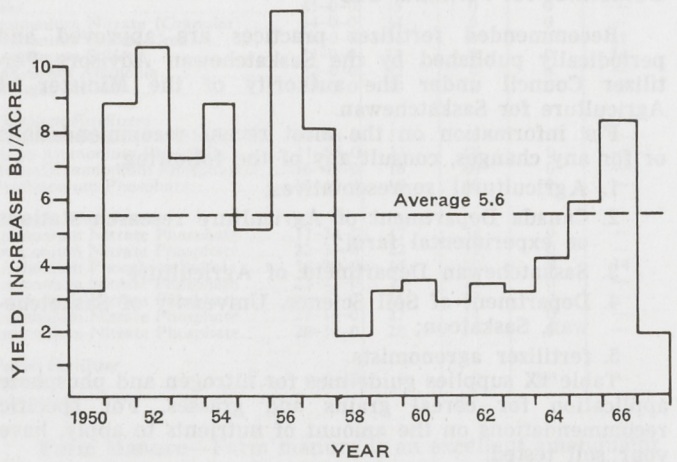


Fig. 5—Average annual increase in wheat yield from 40 pounds per acre 11-48-0 on Sceptre clay

7. Variations in yield, date of maturity, and stand within single fields are reduced considerably with adequate phosphorus fertilization.

8. The use of phosphorus generally helps produce crops with a stronger straw, and thus reduces lodging. It also increases resistance to browning root rot and other crop diseases.

9. Phosphorus fertilization usually increases yields of straw, thus providing a greater potential trash cover for better erosion control.

Fig. 6—The value of nitrogen fertilizers on stubble fields with a very low soil test is illustrated in this test on the Minky farm near Kelvington. The strip to the right of centre received no fertilizer and yielded only 5.6 bushels per acre. The strip to the left of centre received 60 pounds per acre of 11-48-0 (drilled in with seed) plus 220 pounds per acre of 34-0-0 (broadcast) and yielded 26.0 bushels per acre.

Nitrogen for Fallow Cereal Crops—Nitrogen is usually in adequate supply for cereal grains in soils that have been summerfallowed. However, under some circumstances even summerfallow fields may require additional nitrogen. Sandy soil, particularly in the Gray-Black and Gray soil zones, are the soils most likely to be deficient in nitrogen. Nitrogen may also be in short supply in fallowed soils if a heavy growth of weeds occurs during the fallow period. **Soil testing is the most reliable means of predicting nitrogen deficiencies for fallowed soils.**

Nitrogen and Phosphorus for Stubble Crops—Fertilizer requirements for stubble-seeded crops are less predictable than those for summerfallow crops, as both nitrogen and phosphorus may be in short supply. Stubble land is at least as deficient in phosphorus as fallow land. Hence, any fertilizer practices followed on second, third, or fourth crop land should include phosphorus fertilization.

The supply of available soil nitrogen depends on: The amount and type of organic matter, activity of soil microorganisms, yield of previous crop (crop removal), amount of crop residue worked into the soil, past cultural and cropping practices, and climatic conditions. **The need for nitrogen fertilization on stubble land thus varies widely from year to year** and for a particular field may range from none to more than 60 pounds of N per acre. (See Fig. 6.)

Fertilizers such as 23-23-0 or 16-20-0 have proven valuable in overcoming deficiencies of phosphorus and nitrogen in stubble soil. Yield increases in the range of 5 to 10 bushels per acre can be expected for wheat, depending on the supply of nitrogen in the soil.

Excessive rates of nitrogen placed with the seed may cause germination damage. If urea is the nitrogen source then rates in excess of 25 pounds of N per acre should be broadcast. If ammonium nitrate is the nitrogen source then higher rates may be placed with the seed of cereal grains, providing the seed-bed is moist. If the nitrogen required is greater than the rate that can be safely applied with the seed, the nitrogen should be applied separately as a broadcast treatment either in the fall or before the first tillage in the spring. Incorporation in the soil will ensure no loss to the atmosphere.

Broadcast nitrogen often encourages excessive growth of weeds such as wild oats. Hope for yield increases may be sharply reduced unless weed growth is controlled.

Where separate applications of nitrogen fertilizer are used, phosphorus (11-48-0 or 11-55-0) must be placed with the seed or yield increases may be disappointing, and a serious delay in maturity may occur.

Optimum fertilizer practices for stubble-seeded crops can only be determined by a soil test.

Nitrogen for Grasses—Nitrogen fertilizers will improve the yield and quality of hay and pasture. For grass seed production the fertilizer should be applied immediately after the seed harvest. Carry-over benefits from year to year (residual response) often occur when the response in the year of application is low.

Older stands of grass may be markedly improved by nitrogen fertilization. However, a reasonable sward is necessary.

Phosphorus for Grasses—Phosphorus applications for grasses, either preplant or established stands, are recommended only on the basis of a soil test.

Special Fertilizer Practices

Legumes on Gray (Wooded) Soils—Sulfur-bearing fertilizers should be applied prior to seeding. If the legume is established with a companion crop in a separate operation, apply the sulfur by using 16-20-0 with the companion crop. On established stands, apply annually any one of the three sulfur carriers listed below, either in the late fall or early spring:

21-0-0 at 30 to 80 pounds per acre or
16-20-0 at 50 to 150 pounds per acre or
Gypsum at 40 to 100 pounds per acre.

The lower rates of application are recommended for seed production and the higher rates for hay crops. Gypsum, a powder, is difficult to apply with a standard fertilizer attachment.

Grass-Legume Mixtures—On hay or pasture stands, an application of 16-20-0 or 23-23-0 at 100 to 200 pounds per acre is suggested. To maintain the legume in a mixed stand, excess nitrogen should be avoided.

Cereal Grains Following Grasses and Grass Legumes—Where grains are to be sown after forage crops, follow the guidelines suggested for stubble crops. (See Table IX.)

Rapeseed and Mustard—When seeded on fallow land, these crops should be fertilized with phosphorus at a rate of 0 to 20 pounds P_2O_5 per acre. The fertilizer should be applied with a fertilizer attachment mounted on the seeding unit as for cereal. Care must be taken in fertilizing rapeseed seeded on stubble land to ensure that germination damage does not occur. No more than 10 to 12 pounds of nitrogen should be placed with the seed. This is equivalent to 50 pounds per acre of 23-23-0. Separate applications of nitrogen at 25 to 40 pounds per acre and of phosphorus at 0 to 20 pounds of P_2O_5 per acre should be used.

Fall Rye—Fall rye should be fertilized at the same rates used for other cereals.

Field Peas and Beans—Apply 0 to 10 pounds P_2O_5 per acre with the seed.

Potatoes—When planted on fallow land potatoes should receive a side-band application of 35 to 45 pounds P_2O_5 per acre. In a continuous cropping program an additional 50 to 70 pounds of N per acre are recommended. On sulfur-deficient Gray (wooded) soils, use 16-20-0 at 300 pounds per acre. All fertilizers are best applied 2 inches to the side and slightly below the depth of the tubers.

Irrigated Crops

All phosphorus-containing fertilizers should be placed with the seed unless otherwise indicated.

Efficient use of irrigated land does not include summerfallow. However, in the developmental stage in many irrigation schemes in the province, a fallow period is included. Consequently, references are made in the following recommendations to fertilizer use on irrigated fallow land. The most efficient rates of fertilizer applications should be determined by a soil test.

Cereal Grains—For stubble-seeded crops, broadcast 35 to 60 pounds of N per acre before tillage in the spring. Apply 20 to 35 pounds of P_2O_5 per acre with the seed. Where these crops are grown on fallow land or land plowed out of alfalfa, the additional broadcast nitrogen may not be required.

Rapeseed and Mustard—For stubble-seeded crops, broadcast 40 to 70 pounds of N per acre before tillage in the spring. Apply 0 to 20 pounds of P_2O_5 per acre with the seed. Where sown on fallow land or on land plowed out of alfalfa, the additional broadcast nitrogen may not be required.

Potatoes—The fertilizer should be placed 2 inches to the side and slightly below the tuber. In a continuous cropping program apply 125 to 150 pounds of N per acre and 40 to 60 pounds of P_2O_5 per acre. When seeded on fallow land or after a legume crop, lower rates of nitrogen may be sufficient.

Sugar Beets—In a continuous cropping program, broadcast 75 to 100 pounds of N per acre before seeding. Apply 35 to 45 pounds of phosphate per acre at time of seeding. On fallow or on land plowed out of legumes, fertilize at time of seeding using 35 to 45 pounds of P_2O_5 per acre. The phosphorus fertilizers must be placed adjacent to, but not in contact with, the sugar beet seed.

Corn—Side-band 20 to 35 pounds of P_2O_5 per acre at the time of seeding and side-dress with 60 pounds of N per acre when the corn is 6 inches high.

Field Peas and Beans—Apply 0 to 20 pounds of P_2O_5 per acre with the seed.

Alfalfa—Broadcast 40 to 60 pounds of P_2O_5 per acre in late fall or early spring.

Grass-Legume Mixtures—On hay or pasture stands an application of 16-20-0 or 23-23-0 at 150 to 250 pounds per acre is suggested. To maintain the legume in the stand, excess nitrogen should be avoided.

Grasses—For hay production, apply 40 to 130 pounds of N per acre in the fall or very early spring. For seed production, apply nitrogen immediately after harvest. Phosphorus fertilizers should be used only when the need is indicated by a soil test.

Crop rotations are essential to maintain soil fertility under irrigation. (See Cropping Practices section, page 128.)

Soil Tests

The fertilizer recommendations in the preceding section are general guides. Soil testing is the basis for a sound fertilizer program. There are now three types of soil tests that can be requested:

1. The "Complete Test"—This test covers all situations. It gives analyses and recommendations for nitrogen, phosphorus, and potassium. Analyses are also done for sulfur in areas where deficiency may occur. Salinity measurements are also made in the Complete Test. The Complete Test requires samples to be submitted from the three standard depths (i.e., 0-6 inches, 6-12 inches, and 12-24 inches).

2. The "Nitrate-Only Test"—This test gives only a recommendation for nitrogen and is designed mainly for stubble fields on which a Complete or "Fallow-Only" soil test has been obtained recently. It requires samples from the same three sample depths as for the Complete Test.

3. The "Fallow-Only Test"—This test is designed for fields that have been fallowed and it gives a recommendation for phosphorus and potassium. For this test a sample from only the 0- to 6-inch depth is required. The Fallow-Only Test should not be used if you have any reason to suspect a possible nitrogen or sulfur deficiency.

Summerfallow fields should be sampled for a Complete Test at least every 4 or 5 years to ensure the most

profitable use of commercial fertilizers. Stubble fields or continuously cropped fields should be sampled annually. On fields which have recently had a Complete Test, use can be made of the Nitrate-Only Test.

The soil testing reports received by farmers now include an estimate of the yield increases that might be expected from the use of a range of nutrient input. Expected yield increases for various rates of phosphorus are given for summerfallow fields. Expected yield increases for different rates of nitrogen are given for stubble fields. This information will allow a farmer to adjust the specific recommendation given by the Laboratory to suit his conditions of fertilizer cost and grain price. These adjustments of recommendations to suit specific cost and price situations are more often required for nitrogen fertilization on stubble than for phosphorus fertilization on fallow.

For more information on how to use the services of the Soil Testing Laboratory in your farm management program, consult the soil testing bulletins listed at the end of this section or contact:

1. Saskatchewan Soil Testing Laboratory, Department of Soil Science, University of Saskatchewan, Saskatoon; 2. agricultural representatives; 3. fertilizer agronomists.

SPECIAL SOIL PROBLEMS

Saline Soils

Saline soils contain sufficient soluble salts to reduce plant growth. Salts in soils reduce the availability of water and upset the nutrient balance. These salts consist mainly of sodium and magnesium sulfates. Calcium sulfate also occurs but is not as harmful to plants. Saline soils occur widely in Saskatchewan and are a major problem on some farms. About 5,000,000 acres of cultivated land are adversely affected by salinity, including 1,000,000 acres that are severely affected.

When salts are present in large amounts, they appear as a white crust in dry weather. This condition is often referred to as "**white alkali.**" Where less salt is present, the soil is grayish in color when dry and the subsoil often has concentrations of salts appearing as specks at a depth of 6 to 10 inches or deeper. While a good cover of native vegetation may be present, the plants are commonly of low nutritional value. The appearance of the soil and of the vegetation is, therefore, a useful indication of the presence of salinity. Since the salts are soluble, they commonly accumulate in low, flat, and depressional areas to which they are carried by water and left as the water evaporates.

Crop production on saline areas may be improved by: a. The use of manure or green manure; b. growing salt-tolerant crops; and c. the improvement of surface and subsoil drainage. There is no chemical treatment which will remove salts or neutralize their effect. However, fertilizers may promote better growth of grains and grasses on soils with slight to moderate salinity.

TABLE X

Effect of Salinity on Common Crops

Degree of Soil Salinity	Effect on Annual Crops	Effect on Forage Crops
Little or no salinity (below 2 mmhos/cm)	No significant effects on most annual crops.	No significant effects on most forage crops.
Slightly saline (2.0-4.0 mmhos/cm)	Wheat, oats, and flax slightly affected. At 4 mmhos/cm flax, oats, and wheat yields reduced up to 50%.	Red clover, timothy not tolerant. Alsike and Reed canary slightly tolerant.
Moderately saline (4.0-6.0 mmhos/cm)	Rape, barley are slightly affected. At 6 mmhos/cm barley and rape yields may be reduced up to 50%.	Crested wheat, intermediate wheat fairly tolerant. Sweet clover and alfalfa tolerant, but difficult to establish.
Severe salinity (6.0-10 mmhos/cm)	Most annual crops not tolerant and not recommended.	Brome grass, Russian wild rye, and slender wheat grass tolerant.
Very severe salinity (10-15 mmhos/cm)	Annual crops not tolerant and not recommended.	Tall wheat grass tolerant.

Saline soils should not be fallowed because this tends to bring more salts to the surface, accentuating the problem. Saline areas should be cropped continuously, or seeded to long-term forage crops.

The choice of crops which can be grown on saline soils should be based on a soil test.

Table X indicates the relative tolerance of the common agricultural crops to saline soil conditions. (See Forage Crops section for suitable mixtures for saline areas, page 55.)

Soil Reaction (Acid, Neutral, and Alkaline Conditions)

Soil reaction refers to the state in which a soil is said to be acid (or sour), neutral, or alkaline. The actual reaction of a soil is indicated by numbers on what is called the pH scale. Soils of pH 7 and near that figure are said to be neutral in reaction. Soils of below pH 7 are acid, while soils of above pH 7 are alkaline.

Saskatchewan farmers, except in a few isolated areas, need not be concerned with the reaction (pH values) of the soils used for common crops. Very acid reactions (pH 5.5 and lower) and very alkaline reactions (pH 8.5 and higher) represent soil conditions unfavorable for the growth of common crops. Such conditions are rarely encountered in Saskatchewan, where most of the cultivated surface soils range in reaction from slightly acid (pH 6.1) to a slightly alkaline (pH 7.8). Some areas of Scott loam soils in the general Wilkie-Unity area have pH values as low as 5.0 and have shown responses to additions of lime. If low pH is suspected a soil test should be obtained before applying lime.

Undesirable acidic conditions may occur in some moss peats and in some light-colored forest (Podzolic) soils of sandy texture. Undesirable alkaline conditions may occur locally in some soils. Slightly undesirable alkaline reactions may occur in soils high in lime.

Soils of Eroded Knolls and Ridges

The topsoil on sharp knolls and ridges is usually very thin. On many cultivated knolls and ridges, erosion by water and wind has removed the thin topsoil and exposed the lighter colored material. Such soils are droughty and low in productivity, and it is most important to build up their content of organic matter. This may be done by manuring, or by turning under green manure crops. All crop residues should be anchored. The productivity of the soil may be improved by the use of a nitrogen-phosphate fertilizer. Further wind and water erosion must be prevented, and tillage operations and cropping practices that will aid in erosion control should be adopted.

Sometimes further erosion cannot be prevented while the eroded areas remain under cultivation. When this situation arises, it is advisable to seed the eroded areas to a grass-legume mixture. Further information on erosion control can be obtained in the bulletins listed at the end of this section.

Gray Soils in Depressions

The cultivated surface layer of these soils is light gray to white in color. The subsoil is darker in color, heavier (more clayey) in texture, and the drainage is poor or imperfect. The soils occupy slight depressions in the upland and also the outer margins of wet sloughs and meadows. They occur in the Dark Brown, Black, and Transition (Gray-Black) zones, and appear as small, light-colored areas in cultivated fields.

For all practical purposes, these soils may be regarded as imperfectly drained types of Gray (wooded) soils, since they present similar problems of poor structure and low fertility. Their productivity may be improved by adding organic matter in the form of farm manure, by turning in a forage crop, and by using fertilizer for cereal crops.

These gray soils in depressions do not contain high concentrations of salts and lime, and thus should not be confused with grayish-colored, more poorly drained saline soils.

Peat Soils

Peat soils are often deficient in the three nutrient elements—nitrogen, phosphorus, and potassium.

In shallow peats, where plowing may mix some mineral soil with the peat, coarse grains may be grown successfully on the newly broken land, although suitable forage crops may be better in hastening reclamation.

Deeper peats are best pastured for a few years before breaking. The animals pack and manure the peat and hasten its decomposition into a more desirable state. After breaking and discing, a float may be necessary to smooth the surface. **Heavy packing in preparing the seed-bed** is necessary to ensure even depth of seeding. With the deeper peats, it is usually advisable to grow forage crops for a few years before attempting early maturing grains. **Controlled drainage is essential to successful cultivation of peaty areas.**

The burning of peat leads to a loss of nitrogen and organic matter and may result in the exposure of an infertile mineral soil. Where this has happened, the land should be manured, or clover crops turned in, to restore organic matter.

The Solonetzic or "Burnout" Soils

Solonetzic soils occur in several large areas on the Prairies and in some small areas extend into the margin of the forest. They are characterized by an uneven depth of surface soil and an extremely hard, impermeable subsoil. Virgin or uncultivated areas contain depressions, roughly circular in outline, varying from a few feet to many feet in diameter and from 6 to 12 inches in depth. Where the depressions occur, the topsoil is very thin or absent, and the hard subsoil is exposed.

Crop residues are essential for the maintenance of tilth on these soils. To produce good tilth, all straw should be worked into the soil and tillage should be done when the soil is moist but not wet. These soils cannot be properly worked when they are dry and baked. Proper tillage increases the infiltration of rainfall and conserves moisture.

It is advisable to summerfallow Solonetzic soils of the Brown and Dark Brown soil zones every other year. The summerfallow tillage should begin in early May. The first tillage operation should be of sufficient depth to establish ease of cultivation for the rest of the summerfallow year. The depth of penetration will be less with each succeeding operation, so the first tillage will need to penetrate about 4 inches. The uneven surface of this soil makes cultivation at less than 2 inches impossible. Blade implements, cultivators, and rod-weeders should be used rather than disc implements, except where the trash cover is exceptionally heavy.

Deep plowing of Solonetzic soils to break the extremely hard impermeable subsurface horizon, combined in a rotation with the use of deep-rooted forage crops such as clovers, has in some cases been found to be advantageous. Deep plowing is recommended on a trial basis only.

Seeding is usually done early when the soil is at its most desirable moisture level. Preseeding tillage is often practiced to help maintain a desirable tilth.

"Burnout" soils tend to improve under cultivation. Some of the surface soil is dragged into the depressions so that the exposed subsoil layer is at least partially covered. The use of modern power equipment and careful, timely soil management have led to the successful farming of many "burnout" soils. The poor physical condition, rather than a lack of plant nutrients, usually limits crop production on these soils.

Garden Soils

Soils used for gardens and lawns should have all the desirable qualities necessary for the satisfactory production of farm crops. However, the need to locate the garden and lawn near the house may prevent the selection of the best soil. In many instances, the natural soil may have been disturbed or altered by building operations. In addition, garden plants vary widely in their response to soil conditions. Hence, garden soils may require special management.

It is particularly important that the garden soil has good structure, is well drained, and free from harmful quantities of soluble salts and lime. Undesirable soil conditions may be indicated by unsatisfactory growth of certain garden plants. For example, corn is severely affected by saline conditions, while potatoes are moderately affected. Fruits and many flowers and shrubs are severely affected by salinity, and also by excessive amounts of lime, which are associated with undesirable alkaline reactions (high pH values). A soil test will determine if such undesirable soil conditions exist.

Information on the management of garden soils, including the use of organic materials and commercial fertilizers, is contained in **A Gardener's Guide to Soil Fertility,** listed below. For information on recommended varieties and the culture of plants for gardens, shelterbelts, and lawns see Horticulture section.

REFERENCES

Extension Division, University of Saskatchewan

A Gardener's Guide to Soil Fertility. Publ. 169.
Guideline to Soil Sampling. Publ. 197.
Guide to Understanding Saskatchewan Soils. Publ. 175.
Introducing Expected Yield Increases. Publ. 214.
Saskatchewan Soils, Their Productivity and Management. Publ. 201.
Saskatchewan Soil Survey Report No. 12 (up to Twp. 48).
Saskatchewan Soil Survey Report No. 13 (settled areas north of Twp. 48).
The Soils of the Regina Map Area. Publ. 176.
The Soils of the Rosetown Map Area. Publ. 202.
The Soils of the Willow Bunch Lake Map Area. Publ. 200.

BEEKEEPING

SASKATCHEWAN HONEY PRODUCTION

Saskatchewan honey is produced mainly from sweet clover, alfalfa, rapeseed, alsike clover, red clover, and fireweed, There are approximately 45,000 colonies in the province, annually producing between seven and eight million pounds of honey. Saskatchewan honey is marketed within the province, throughout Canada, and overseas. Approximately 85 percent of the Saskatchewan honey crop is produced by beekeepers with 100 to 1,600 hives of bees. The balance is produced by hobby beekeepers or people who keep from 1 to 100 hives of bees. The price returned to the commercial honey producer over the past 10 years has averaged 14 cents per pound.

STARTING WITH BEES

Bee Stings

A beekeeper expects to receive some bee stings. Experienced beekeepers learn how to avoid stings, and the stings they do receive do not bother them unduly. A little cool smoke from the bee smoker controls the bees during hive examinations and a bee veil protects the face from stings. Any stings received should be scraped away at once to reduce soreness and swelling. A few people are extremely allergic to insect stings and should not keep bees.

Cost

It is advisable to start with one or two hives of bees as a hobby and increase the number of hives as one gains experience. A hive stocked with bees will cost about 40 dollars. A living derived solely from honey production would require 1,000 hives and an investment of about 50,000 dollars.

Bees

Few Saskatchewan beekeepers overwinter their bees. Hives are restocked in April with bees from California. A 2-pound packages of bees complete with queen will cost a beginner approximately 8 dollars delivered.

Supplies

Bees and new beekeeping equipment may be purchased from bee supply firms, and their catalogues will help a beginner to understand some of the equipment necessary for beekeeping.

Used beekeeping equipment is sometimes available from people who are discontinuing beekeeping. In examining used equipment it will be noted that some of the honeycombs are very dark and others are almost white in color. Color is an indication of age. Dark combs are preferred by the bees for brood rearing. Lighter colored combs are used for storing honey.

Anyone wishing to sell used beekeeping equipment is required to obtain a permit which is issued by the Apiary Administrator. The permit will indicate when the equipment was last examined for disease and whether or not disease was found in the equipment. Before buying used bee equipment one should ask to see the sale permit. Beginners are cautioned against buying equipment not covered by a permit or equipment with a history of disease.

HARVESTING THE HONEY CROP

In order to obtain the honey, the honeycomb must be removed from the hive, uncapped by means of a heated blade and emptied of its contents by means of a honey extractor. If bought new, this equipment and a tank to hold the honey will cost approximately 130 dollars.

POLLINATION

One populous hive will pollinate 2 acres of orchard, 1 acre of sweet clover, 1 acre of rapeseed, or 2 acres of alsike clover, provided the bees are not enticed away by competitive bloom. Commercial beekeepers provide bees for pollination in return for the honey their bees obtain.

BEEKEEPING LEGISLATION

The Apiaries Act of the Province of Saskatchewan requires that all Saskatchewan beekeepers register with the Department of Agriculture and be issued with a certificate of registration. The Act also defines the beekeepers' responsibilities in respect to bee diseases and empowers the Minister of Agriculture to implement such action as may be deemed necessary to control an outbreak of disease in an apiary.

The honey-grading regulations under the provincial Vegetable and Honey Sales Act regulate the packaging, labeling, grading, and classifying of Saskatchewan honey sold in the province through wholesale and retail stores.

Federal honey-grading regulations govern the packaging, labeling, grading, and classification of honey moving interprovincially or on the export market. An office of the Federal Fruit, Vegetable, and Honey Division of the Canada Department of Agriculture is located in both Regina and Saskatoon.

ADDITIONAL SOURCES OF BEEKEEPING INFORMATION

The office of the Apiary Administrator, Production and Marketing Branch, Department of Agriculture, Land Titles Building, Prince Albert, Saskatchewan, serves the beekeepers in Saskatchewan by providing information and literature on beekeeping, assisting with problems of disease control in bees, administering the Apiaries Act, and the honey-grading regulations.

The Saskatchewan Beekeepers' Association, Land Titles Building, Prince Albert, promotes, develops, and maintains good fellowship and co-operation among beekeepers and proposes, obtains, and supports governmental legislation helpful to the beekeeping industry.

The Manitoba Co-operative Honey Producers Limited, Tisdale, Saskatchewan, sells bees and beekeeping equipment and co-operatively packs and markets its members' honey.

REFERENCES

ABC and XYZ of Bee Culture. Root.
The Hive and the Honey Bee. R. A. Grout.

Additional Information on Bees in this *Guide*.
Alfalfa Leafcutter Bees, page 61.
Insecticides and Honeybees, page 105.

DAIRY PRODUCTS

SASKATCHEWAN'S DAIRY INDUSTRY, 1970

Number of farms marketing cream	20,000
Number of farms marketing milk	540
Number of milk cows	115,000
Total milk production (pounds)	815,400,000
Value of dairy products	$27,647,000
Number of dairy manufacturing plants	40

Percentage Use of Milk

Factory products	49.8
Fluid milk and cream	22.7
Fed to livestock	6.7
Farm butter	2.8
Farm home consumed	18.0

GUIDE TO BETTER MILKING

1. Avoid exciting the cow.
2. Wash the udder with disposable paper towels soaked in a warm (115 to 120°F) sanitizing solution.* Use separate towels for each cow.
3. Milk the first few streams from each quarter into a strip cup to detect abnormal milk. This milk is generally of inferior quality.
4. Flakes or abnormal milk indicates inflammation. Animals thus infected should be milked last and the milk discarded.
5. Routine use of the Gel Test (California Mastitis, Whiteside, Danish Mastitis) is effective in early detection of abnormal milk. (See Animal Diseases section, page 155.)
6. Attach milking machine within 45 seconds to 1 minute after washing and drying the udder.
7. Strip by machine by pulling down and forward on teat cups. Avoid excessive stripping.
8. Remove teat cups as each quarter is milked out, by breaking vacuum between teat and inflation.
9. Sanitize* inflations after milking each cow by dipping teat cups first in clean water (180°F) and then in a warm sanitizing solution.*
10. After milking, immerse each teat in a recommended teat dip solution to control the entry of disease-producing bacteria into the teat canal.
11. Cleaning and sanitizing solutions should be used at the strength recommended by the manufacturer.

*See reference 1. Available from Saskatchewan Department of Agriculture, University of Saskatchewan, or a milk plant.

MILKING EQUIPMENT

All equipment should be in good working condition for fast, efficient milking and the prevention of udder irritations. Udder irritations, accompanied by the entry of bacteria, usually lead to mastitis.

Pump—Large enough to handle the number of machines used.

Vacuum Line—Large enough to permit a rapid flow of air. Minimum 1½-inch vacuum lines are now recommended.

Regulator—Must be kept clean to react to pressure changes, quickly and smoothly.

Vacuum Gauge—Should be checked periodically to determine accuracy.

Pulsator—Should be clean and be operated at the pulsation rate recommended by the manufacturer.

The Dairy Division has instruments for checking milking equipment. Inquiries should be directed to the Dairy Division, Department of Agriculture, Administration Building, Regina.

CLEANING DAIRY UTENSILS

Poorly washed dairy equipment, such as milking machines, bulk tanks, cream separators, and pails, will add more bacteria to milk than all other sources of contamination combined. A proper cleaning routine is therefore extremely important.

Sanitizers

Sanitizing compounds are chemicals which are used in solutions to destroy bacteria on dairy utensils. Certain sanitizers are also suitable for washing udders before milking and dipping teats after milking.

The three most common types are:

1. Chlorine-containing sanitizers. (These are not the same as "chlorinated detergents!") Chlorine sanitizers are available as liquids or powders and are used for sanitizing dairy equipment. Since chlorine is irritating to the skin, these compounds are **not** recommended as udder wash or teat dip.

2. Iodine-containing sanitizers. These are solutions suitable for sanitizing utensils as well as for washing udders and dipping teats. Iodine compounds are slightly acid, and therefore they aid in the prevention of milkstone formation. The temperature of the solution should not exceed 120°F to prevent discoloration of equipment.

3. Quaternary ammonium compounds. Also called "Quaternaries" or "Quats," they are recommended for udder washing and teat dipping only.

All sanitizers are effective only if equipment surfaces are clean and free of milk residues.

To assure good disinfection, it is important to prepare all sanitizing solutions according to the manufacturer's direction regarding concentration and temperature. If in doubt, contact your dairy plant, any dairy inspector, or the Department of Agriculture, Regina.

Procedure for Cleaning Dairy Utensils

1. **Rinse**—Immediately after use (both morning and evening) rinse all equipment free of milk with lukewarm water. Milking machines should be rinsed by sucking a pail of water through each unit and plunging the claw in and out of the water to improve flushing. Never use hot water for rinsing, as it tends to bake the milk solids onto the equipment.

2. **Wash**—After rinsing, vigorously brush all equipment with a hot solution of an approved dairy cleaner.*

3. **Rinse Again**—Use clean, very hot water. This removes traces of the cleaner and speeds drying of the equipment. Place utensils on a clean drain rack. Do not wipe dry.

4. **Sanitize**—Just before use, sanitize all milking equipment (including milk and cream cans returned from the

*Consult your dairy inspector for direction.

dairy plant) by rinsing with a solution of a bacteria-killing agent such as a chlorine or iodine compound.

Milkstone Removal

Milkstone is a white deposit which may form on milking equipment. It is composed largely of mineral salts from milk, alkaline cleaners, and hard water. The harder the water, the greater the tendency for milkstone to form. Milkstone provides food for bacteria, allowing them to grow to large numbers between milkings, and it lowers the bacteria-killing effect of sanitizing agents. Once visible, it can be removed only with a concentrated acid cleaning solution. The best approach is to prevent it from forming in the first place by using an acid dairy cleaner as required.

Special Cleaning Methods For Milk Machines

1. **Rubber Parts**—The rubber milking tubes and teat inflations of the milking machine should be cleaned and sanitized as described above. In addition, the following treatments are strongly recommended:

a. **Storage Between Milkings**—Soak the rubber parts in a freshly prepared, ½-percent lye-EDTA solution (2 level tablespoons to 1 gallon of soft water). Store short-tube milkers in a crock or plastic container; store long-tube milkers in a solution rack.

b. **Defatting Treatment**—Have two sets of liners. While one set is in use, soak the other in a freshly prepared, 5-percent lye-EDTA solution (12 tablespoons to 1 gallon of soft water) for 1 week. Removing the fat and other milk solids from the rubber extends the life of the liners and tubes. Before using again, rinse the soaked rubber parts with an acid cleaning solution.

Replace teat cup inflations regularly. Cracked or excessively soft or hard inflations are difficult to keep clean and are a source of high bacteria counts in milk.

2. **Vacuum Lines**—To maintain proper vacuum and good milk production, clean the vacuum lines at least once a month* or immediately after milking if milk accidentally gets into the lines.

*Consult your dairy inspector for direction.

COOLING MILK AND CREAM

Rapid cooling of milk and cream to a temperature of 40°F immediately following milking or farm separation is essential. Since air cooling is not efficient, use either cold running water or electrically operated coolers. Running-water troughs might provide satisfactory cooling for small amounts of cream, but some type of mechanical cooling is required for milk.

Mechanical coolers commonly used in Saskatchewan are:

1. **Cabinet Coolers**—These are satisfactory for cooling and storage of milk or cream in cans on small dairy farms.

2. **Bulk Milk Cooling Tanks**—These units provide ideal cooling and storage of milk on the farm. Furthermore, they have eliminated the problems long associated with the use of 8-gallon cans. Bulk cooling and storage are strongly recommended where bulk pickup is available.

Efficient cooling should not be considered as a substitute for careful production. Bulk tanks are designed to protect the quality of milk produced according to the requirements for high-quality production outlined above.

To improve the general quality of raw milk, a bacterial standard was established in Saskatchewan. The regulation for the number of bacteria is a standard plate count (SPC) of not more than 75,000 per milliliter. With efficient cooling as found in bulk tanks, bacterial counts are usually much lower, **if the milking equipment is clean and sanitary.** However, if the temperature of the milk is allowed to rise above 40°F and/or if the milking utensils are neglected and unclean, bacteria will be present in very large numbers in milk. Fluid milk producers with adequate cooling facilities and properly washed and sanitized equipment will have no difficulty in meeting the present standard.

CREAM PRODUCTION

If the dairy industry hopes to maintain the sale of butter at a premium price over substitute products, it must increase its efforts to improve further the flavor and keeping quality of butter. The best quality butter is made from fresh, sweet cream, free from objectionable flavors. Every effort, therefore, must be made to protect the quality of cream on the farm.

1. Keep the number of bacteria in the cream low by following the steps outlined previously for cleaning dairy utensils. The cream separator will add billions of bacteria to the milk and cream unless it is washed after each use. Washing the separator only once a day is unsanitary, and results in rapid souring and spoilage of cream.

2. Cool the cream quickly to 40°F or lower in cold, running water or in some form of mechanical cooler. Do not allow it to freeze.

3. Do not mix warm cream with cold cream.

4. Avoid the use of rusty cream cans and utensils.

5. Do not feed strongly flavored feeds within 3 hours of milking.

6. Ship the cream fresh if possible and preferably not over 3 days old.

7. Cover cream in home coolers to avoid absorbing off-flavors from other products.

8. Avoid using home freezers for cooling and holding cream. Freezing changes the physical appearance of cream, making it unattractive and causing sampling and processing troubles.

9. Protect the cream at all times from sunlight, freezing, and dust, particularly while on the way to the creamery.

10. **Sediment Control**—Prevention is better than cure. No foreign matter should be allowed to enter the milk or cream at any time, because it is most difficult for the butter manufacturer to remove sediment from the cream. One of the routine analyses performed by the Canada Department of Agriculture is a test for sediment in butter. Since the major portion of foreign matter in butter comes from farm-separated cream, producers are urged to handle cream with the greatest possible care. Any contamination with foreign material—dust, straw, hair, flies, etc. — during milking, separating, storage, and shipping must be avoided in order to produce cream suitable for making first-grade butter.

Cream is purchased in Saskatchewan under the following "Cream Grades:"

Special: Clean flavor, uniform consistency, not frozen. Acidity not over 0.30 percent.

First: Suitable for making Canada First Grade butter; reasonably clean in flavor, uniform consistency, higher acid content than special.

Second: Weedy, bitter, stale, musty, metallic, or frozen.

Reject: Unsanitary, contains a foreign substance or is unfit for human consumption. It will be tagged rejected, have a harmless coloring matter added, and be returned at the producer's expense.

Producers can obtain at least 4 cents more per pound of butterfat for special grade cream than for first grade, and at least 5 cents more for first grade than for second.

PASTEURIZATION OF MILK IN THE HOME

Families who routinely use fluid milk in raw form risk contracting any of several diseases which may be transmitted from cattle to humans. Occasionally, contagious abortion is discovered in a dairy herd following testing prompted by an attack of undulant fever in some member of the family. Home pasteurization units are available from most mail-order houses to prevent such misfortunes. As a simple

alternative, milk may be made safe for home use by heating in a double boiler to a temperature of 165°F and then cooling in water as quickly as possible.

PROTECTING MILK FROM ANTIBIOTIC AND PESTICIDE RESIDUES

The Food and Drug Act prohibits antibiotic and pesticide residues in milk and milk products because they may be injurious to human health. Regular checks are made on milk supplies for these residues.

Antibiotics are commonly used in the treatment of mastitis. To avoid harmful residues, the milk from treated cows must not be shipped to the dairy plant for six milkings or as indicated on the label of the antibiotic container. **Read and Heed the Label.**

The Food and Drug Administration has strongly warned against allowing dairy animals to feed on plants, forage, or ensilage that have been treated for insect control with recommended chemicals. Some pesticides, if consumed with feed, will appear in the milk as residues harmful to humans. Precautions must also be taken in the use of chemicals for fly control. When in doubt about the safety of a pesticide, consult your local agricultural representative, dairy fieldman, or the Entomology Division, Canada Agriculture Research Station, Saskatoon. (See reference 2, and Insect Pests section, page 105.)

FLAVOR DEFECTS IN MILK

The three most common causes of flavor defects are feed and weeds, poor cooling, and improperly cleaned and sanitized equipment.

When cows feed on rapidly growing grass or grain crops and on weeds, the milk takes on a "feed" or "weed" flavor. This can be minimized by taking cows off pasture at least 3 hours before milking. Strongly flavored feeds such as silage and weedy hay should be fed only after milking.

Barns must be clean and well ventilated because any odor present in the barn will be inhaled by the cow, absorbed into the blood stream, and transferred to the milk.

Allowing either milk or cream to remain above 50°F for any length of time will permit bacteria to grow, causing sourness and other off-flavors. Therefore, quick cooling to 40°F is most important in maintaining good flavor.

Bacteria grow on unclean, moist equipment. When milk or cream comes in contact with these utensils, the bacteria will cause such off-flavors as sour, malty, stale, cheesy, or bitter. Follow the instructions outlined for cleaning dairy utensils.

Rancid and bitter flavors result from the breakdown of fat in milk and cream and may occur when the milk is from cows in late lactation, or when there is too much agitation during cooling, or when the temperature of the milk or cream is allowed to rise and fall again. A salty flavor is common in milk from cows in late lactation and from those with infected udders.

VARIATIONS IN BUTTERFAT TESTS

Variations will occur in butterfat tests of successive shipments of milk or cream produced under apparently uniform conditions. The fat content of milk from individual cows is not as constant from day to day as is commonly believed. Some of the factors which could change the fat test include: condition of cow at calving, stage of lactation, completeness of milking, time interval between milkings, season of year, period of "heat," and sudden changes in feed.

Variations in voltage with power-driven cream separators, resulting from heavier loads at certain times of the day, can change the speed of the separators and consequently the results of the cream tests. These and other sources of variations must be expected, and should not result in misunderstanding between producer and purchaser.

USE OF DAIRY BY-PRODUCTS ON THE FARM

The food value of skim milk is not always appreciated. Whole milk normally contains 12 percent solid material; about 8.5 percent is still left in the skim milk. These food solids have great nutritional value, as they are rich in growth-promoting proteins, vitamins, and bone-building material. Skim milk is, therefore, an excellent food for growing children and for the maintenance of health in adults. Skim milk and buttermilk are also of particular value in rations for pigs, calves, and poultry.

REFERENCES

Reference Bulletins Cited in Section

1. *Dairy Equipment Cleaning Procedures, Detergents and Sanitizers.* Saskatchewan Department of Agriculture.
2. *Recommended Chemicals for the Control of Livestock Insects in Saskatchewan.* Saskatchewan Department of Agriculture.

Other References

Canada Department of Agriculture

Dairy Cow Housing and Equipment (Canada Farm Building Plan Service).
High Quality Milk. Publ. 844.
Mastitis Must Be Beaten. Publ. 1082.

Saskatchewan Department of Agriculture

Annual Report.
Dairy Herd Improvement Services.
The Dairy Products Act.
The Margarine Act.
Market Top Quality Cream.
The Milk Control Act (Milk Control Board).
Regulations Under the Dairy Products Act.
Regulations Under the Margarine Act.
Regulations Under the Milk Control Act (Milk Control Board).
Why Cream Tests Vary.

Other Publications

Farm Care of Utensils and Cooling Milk and Cream. Publ. 146. Extension Division, University of Saskatchewan.
The Food and Drug Act. Canada Department of National Health and Welfare.
Regulations Governing Milk and Certain Milk Products. Saskatchewan Department of Public Health.
Safe Milk by Home Pasteurization. Canada Department of National Health and Welfare.

INSECT PESTS OF PLANTS AND LIVESTOCK (For figures, see color section, pages 83 and 84.)

Damage from insects affecting crops and animals can usually be reduced or eliminated by a combination of cultural methods and management practices, and the proper use of recommended insecticides.

Cultural and management practices should be used wherever possible; greater attention to this approach may lessen the need for insecticides.

When insecticides are essential to prevent economic loss, they should be used strictly in accordance with the latest recommendations.

Chemical control recommendations given in the tables may change with the introduction of safer or more effective compounds. They may also change with changes in legislation governing the types and amounts of residue permitted in food and feed products. **Therefore, growers should also see the latest revisions of publications such as Saskatchewan Department of Agriculture Publication No. 622 dealing with field crop insects and No. 625, dealing with insect pests of vegetables, ornamental and fruit trees, and shelterbelt and shade trees.**

WIREWORMS (See Figs. 1 and 2)

Wireworms are slender, hard-bodied, shiny, yellow worms, the largest about 1 inch long. They do not curl up when disturbed as cutworms do. Each year some wireworms reach full growth and change to a pupal or resting stage during July. The pupae usually are found in the top 3 inches of soil. In about 2 weeks they change to "click" beetles which overwinter and lay eggs in the soil the following spring. Tiny wireworms hatch in June and early July. These worms may live for 5 to 10 years in the soil. They move only short distances. A field may remain infested for years, though damage may be noticed only in crops seeded on fallow.

Damage—Wireworm damage to cereals is indicated by thin, patchy stands. Stands usually are heavier in the wheel tracks of seeding equipment than between them.

Damage is generally heaviest in crops seeded on summerfallow or on rebroken grassland. Patches may gradually enlarge and eventually become bare. With severe damage, the whole crop may be destroyed. Wireworms attack and destroy seeds but most damage occurs at the seedling stage. The underground stems are bored into and shredded, but not cut off. The outer leaves of older plants generally remain green for some time after the central shoot is killed. Potatoes and other root crops are damaged by wireworms tunneling in the tubers, stems, and roots. Other susceptible garden plants may be killed by damage to underground parts.

Choice of Crops—Wireworms attack all grain crops, especially wheat and spring rye. Oats and barley can be seeded safely if recommended seeding practices are followed, except when wireworm infestations are severe. Flax and rapeseed are seldom damaged except in heavy infestations. Winter wheat, fall rye, sweetclover, and alfalfa usually escape serious injury. Corn, sunflowers, or potatoes should not be seeded on infested land unless a chemical control is used.

Control

Cultural Practices—Use clean summerfallow every 2 or 3 years where summerfallowing is a recommended practice. 1. Destroy all green growth during June and July to starve newly hatched wireworms. 2. Work summerfallow as shallowly as possible for weed control; deep cultivation may increase wireworm numbers.

Follow recommended seeding practices to increase plant vigor and reduce wireworm damage. Seeding too deeply will reduce the effectiveness of seed treatment. Avoid very early or very late seeding.

Land on which a cereal crop has been destroyed by wireworms usually can be reseeded immediately without danger of further serious damage.

Seed Treatment on Cereal Crops—Powder or liquid insecticide seed treatments will give immediate control of wireworms in cereal crops. An insecticide may be used alone for wireworms only, or in combination with a fungicide (dual-purpose) for the control of seed-borne diseases as well. (See Plant Diseases section, page 116.) The seed dressings may be applied and mixed by hand or with mechanical seed-treatment applicators and mixers. There are also special powder formulations for application to the seed in the drill box at the time of seeding.

Use sound, dry seed and treat uniformly. **Apply the dressing at the rate recommended on the label.** For good disease control apply dual-purpose dressings to wheat at least 1 day before seeding, and to oats and barley at least 1 week before seeding, unless directions on the container state otherwise. Powder dressings may be applied any time during the winter or spring before seeding. Longer storage may damage seed and reduce wireworm control. With liquids, follow the directions on the label.

If damp or tough grain must be seeded it should not be treated more than a few hours before seeding.

Seed treatments give better returns on grain planted in fallow or rebroken grassland than on grain planted in stubble. Watch summerfallow crops for wireworm damage; when damage is found plan to treat the seed for the next summerfallow crop.

Seed regulations state that any grain seed treated with a poisonous material shall be stained with a conspicuous color and the container shall be marked as follows: "Poisonous; do not use as a feed. This seed has been treated with . . . (name of poisonous substance)."

Handle all treated grain seed so that none of it can be eaten by domestic or wild animals, or birds.

Seed Treatments on Crops Other Than Cereals—Seeds of corn, beans, sugarbeets, and sunflowers can be treated to prevent damage by wireworms. Dual-purpose dressings containing mercury should not be used on legumes because mercury is harmful to the nitrogen-fixing bacteria and to the seeds themselves.

Do not treat potato seed pieces with insecticide, as this may reduce germination and plant development.

Chemical Soil Treatments—Insecticide soil treatments are too expensive for grain crops and are recommended only for crops expected to give larger returns per acre—such as potatoes. The chemical should be applied to the surface and worked immediately into the top 4 to 6 inches of soil. The land should then remain practically free of wireworms for several years without further treatment. Watch for signs of wireworm damage each year, and treat again when necessary.

Band treatments of insecticide, applied on each side of potato seed pieces, will give good protection to the potatoes in light wireworm infestations only. These treatments usually are applied with a planter-fertilizer applicator during planting.

CUTWORMS

Cutworms have fleshy, soft bodies and when disturbed usually curl up and remain motionless. The two most common kinds that attack seedling crops in the spring are the **pale western cutworm** and the **red-backed cutworm.** The pale western cutworm is a uniform pale-gray color and is a pest of the Prairies and margins of the Parkland. The red-backed cutworm is moderately dark gray on the top half of the body and has two broad, dull-red stripes along the back. It normally occurs in the Park and Forest Belt but may extend well into the prairie area. It may be found in gardens throughout Saskatchewan.

Both kinds of cutworms feed mainly at night, cutting off the young stem at or below the soil surface. In dry soil the cutworms may be found 2 to 3 inches deep instead of at their usual location near the surface. They will attack all field and garden crops. Damage normally occurs from late in May until the end of June, but occasionally continues into July. When full grown, 1½ to 2 inches long, they change to brown pupae 2 to 4 inches deep in the soil. The moths emerge from the pupae and lay their eggs in the soil from mid-August to mid-September. The eggs hatch in the spring. A field that is infested one year may or may not be infested the next.

Several kinds of cutworms hatch in the fall and overwinter as partly grown larvae. The larvae feed on weeds and volunteer grain until freezeup and again in the spring. They usually finish feeding before the spring-seeded crops emerge. Occasionally one kind, the **army cutworm,** becomes very abundant in summerfallow fields in Southwestern Saskatchewan. If crops are seeded early or the larvae are feeding later than normal they may cause serious damage. They can be controlled with an insecticide spray.

Climbing cutworms, mainly the **flax bollworm** and the **bertha armyworm**, occur on crops in July and August. All overwinter as pupae in the soil. The moths emerge in midsummer and lay their eggs on the host plant. (See Table II of this section for information on these cutworms.)

Red-Backed and Pale Western Cutworm Control

Cultural Control—Red-backed cutworm moths lay their eggs in weedy patches on summerfallow or in crops. In the Parkland area if tall weeds develop on summerfallows after mid-August, work them down to discourage egg-laying.

Moths of the pale western cutworm lay their eggs in loose soil regardless of vegetation. In areas where this cutworm was a problem in early summer avoid working summerfallow between August 1 and September 15 to allow a crust to form on the soil. Should weeds develop, however, they should be worked down.

The primary purpose of summerfallowing, moisture conservation through prevention of weed and volunteer growth, should not be sacrificed for pale western cutworm control. Loss of moisture from a weedy summerfallow field is a certainty, while cutworm infestation in most years is a low risk that can be handled with insecticides if necessary.

Chemical Control—Examine crops every few days after they emerge, looking for damage and cutworms. First signs of damage are holes and notches in the leaves; later, plants are cut off. The cutworms are small and easily overlooked at this time but usually they can be found by scratching in the soil around cut plants, including weeds. One or two cutworms per square foot can cause severe damage, especially in rapeseed and flax. Spray infested fields with currently recommended insecticides as soon as damage is seen. (See Table II.)

Reseeding of damaged fields is not safe until the cutworms have been killed by chemicals or have stopped feeding (usually by the end of June).

GRASSHOPPERS

Over 75 different kinds of grasshoppers have been found in Saskatchewan, but only three or four damage field and garden crops. These, and most others, overwinter in the soil as eggs that hatch in the spring. A few harmless kinds winter as partially grown grasshoppers and their appearance early in the spring often gives rise to incorrect reports that grasshoppers have begun to hatch.

Nearly all Saskatchewan grasshoppers lay their eggs in the upper 1½ inches of soil in pods containing 10 to 80 eggs (see Fig 3). Hatching occurs from late May to July, depending on weather conditions.

The newly hatched grasshoppers resemble adults but are wingless, and only about one-eighth of an inch long. As they grow, they shed their skins about once a week, usually five times, becoming full grown and winged in early summer. Egg-laying may continue as long as food is available and the weather remains warm enough.

Grasshopper Breeding Grounds

Spring infestations of grasshoppers come from: 1. Egg beds adjacent to cultivated fields on roadside sod, on borders of sloughs, in pastures, and occasionally on ditch banks, drift ridges, and banks of irrigation canals; 2. eggs scattered throughout stubble fields.

Clean summerfallow even with heavy trash is free of troublesome numbers of eggs.

In Saskatchewan, large areas of native grassland are rarely breeding grounds for grasshoppers harmful to field crops. Other kinds of grasshoppers may increase in native grasslands sufficiently to become troublesome, but these rarely invade fields crops. Infestations may appear to come from such grasslands if young grasshoppers are first driven off stubble fields and then return to crops, or if egg beds occur on native sod between crops and open range. Such egg beds are associated with crop land and not with the native grasslands.

Grasshopper Control

The Grasshopper Forecast—Watch the annual forecasts for information on the expected extent and severity of outbreaks for the coming season. These forecasts provide the guide to individual and community planning for grasshopper control.

Seeding Infested Stubble Fields—Stubble fields are poor risks for cropping during years of combined drought and grasshopper outbreak; do not sow crops in them unless you are prepared to spend extra time and money to protect them. There is no known tillage method by which fields containing "moderate," "severe," or "very severe" egg infestations can be made completely safe for crop production. Handle infested stubble fields so as to prevent grasshoppers that hatch in them from invading crops on summerfallow.

Starvation Control on Stubble Land To Be Fallowed—Newly hatched grasshoppers can be starved to death before they can move out of a field. To do this have all green growth destroyed at hatching time. Grasshoppers which hatch on the edges of stubble fields may escape into adjacent crop margins. Watch for damage from this source.

If partly grown grasshoppers are present at the time of a tillage operation, apply chemical control in one of the following ways: 1. Spray the entire field before tillage; 2. poison them promptly as they enter grain fields.

Chemical Control—Keep a close watch during hatching time; individual farms may have worse grasshopper problems than the forecast would indicate. Watch for grasshoppers in areas of sod near cultivated fields, in pastures, in seedling crops sown on stubble lands, in neglected stubble fields, and in the margins of other crops.

Control young grasshoppers by spraying them where they have hatched and before they have spread over a larger area or have moved into adjacent cropped fields. (See Table II of this section.) Grasshoppers already invading a grain field should be sprayed immediately.

During fine weather, immense numbers of grasshoppers may hatch from an egg bed each morning for several days, and move into nearby crops quickly. Do not expect one spray treatment to give adequate protection for more than 3 or 4 days. Be prepared to repeat the treatment when necessary because of additional hatching or invasion.

In fall-sown crops a few adult grasshoppers can cause severe damage to seedling grain. If there are grasshoppers in the standing crops or stubble next to the fields being seeded, spray them before the crop comes up. If the seedling crops are later invaded, spray these and the surrounding crops from which the invasion is taking place.

Natural Control—Grasshoppers have numerous natural enemies which kill them during all stages of growth. These include a large variety of insects, spiders, birds, and small mammals. A fungus disease that is always present can kill many grasshoppers when weather conditions are suitable and may even wipe out a threatening infestation. Dead grasshoppers seen clinging to the tops of tall plants have been killed by this disease. However, in spite of these natural enemies it is usually necessary to protect the crop with sprays.

Cool, damp weather can act as a natural control by reducing the percentage of eggs hatched and increasing mortality among the young hatchlings. On the other hand, warm, sunny weather may greatly intensify an outbreak. In summer and fall it favors an increase in the number of eggs laid; in spring it favors hatching and survival of the young nymphs. In addition, when weather is very hot and dry, the insects grow very rapidly and destroy much more crop than when it is cool. Under drought conditions the crop practically ceases to grow, so that the danger of crop damage increases and enormous losses may occur.

WHEAT STEM SAWFLY

The slender, wasp-like adults are less than one-half of an inch long and are black with yellow legs and narrow yellow bands on the abdomen. Because of their size, color, and habit of flying close to the ground, they are seldom seen. The females lay their eggs inside wheat stems from the middle of June to the middle of July. The white grubs that hatch tunnel inside the stems, destroying each other. Finally, only one remains alive in each stem. Just before harvest, the grub moves to ground level. It girdles the stem from the inside, plugs the upper end of the stub, and overwinters in it. The girdling weakens the stem so that it breaks off. These fallen stems at harvest, and the "sawdust" present inside after mid-July, make sawfly damage easy to recognize. Even if all fallen heads are harvested, sawfly larvae still reduce the yield by 10 to 20 percent.

Sawflies come from the previous year's stubble. If susceptible crops are seeded on or close to infested stubble, serious infestation is almost certain to result.

Wheat Stem Sawfly Control

1. **Seed Immune or Resistant Crops**—Of the sawfly-resistant bread wheats, Cypress is more resistant than Chinook and has higher milling and baking quality than Rescue. These varieties are resistant because they are solid-stemmed. Prolonged cloudy spring weather may result in hollower stems and reduced sawfly resistance. The seeds from these plants will, however, produce resistant plants under normal growing conditions.

Most varieties of durum wheat and barley have some resistance. Oats, fall rye, and oilseed crops are immune to sawflies.

2. **Use Shallow Tillage to Reduce Infestations**—Shallow tillage of stubble between mid-May and the first week of June will expose infested stubs and kill many sawfly grubs. Shallow tillage after harvest is effective.

3. **Use Trap Strips To Protect Vulnerable Crops**—Seed a strip of wheat about 1 rod wide between infested stubble and the crop to be protected. Seed the trap strips earlier than the main crops, and cut them about mid-July to destroy sawfly grubs and eggs. Trap strips are more effective if a bare strip about 1 rod wide is maintained between the trap and the main crop. If a resistant wheat is planted in the trap strip it need not be swathed early in most years.

4. **Swath Infested Crops Early**—If sawfly infestation is 25 percent or more, the crop should be swathed early, at about the late dough stage of the kernels. Swathing at this stage will prevent cutting by sawflies and lodging, although it will cause some loss in yield. It is preferable to wait until the normal time of swathing if infestation is light, or to confine early swathing to a few rounds at the margin of the field if the infestation is moderate. Determine the percent infestation by examining wheat stems for sawfly grubs and "sawdust." Split ten stems taken at the crop margin and at every ten paces into the field for about 100 yards.

5. **Do Not Burn Infested Stubble**—Burning infested stubble will not destroy sawfly larvae, but will destroy many sawfly parasites, which overwinter in the stubble. Parasites help to reduce sawfly populations, especially in years when the crop is late maturing.

INSECT PESTS OF OILSEED CROPS

Many kinds of insects may occur on oilseed crops, but not all are important. Growers should learn to identify the destructive kinds and prepare to use the proper control measures where the pest species are numerous enough to require it. (See Table II for information on chemical control of these pests.)

Application of Insecticides

Control measures must be applied quickly once infestations of economic importance are discovered. On full-grown crops, aircraft spraying has advantages if it can be done promptly. If it cannot, the grower must weigh the cost of mechanical damage to the crop by a ground sprayer against the cost of extra insect damage due to delay.

Flea Beetles (See Fig. 4)

Flea beetles are pests of the seedling stage of rapeseed and mustard. They are small, shiny-black insects named for their habit of jumping quickly when disturbed. They overwinter as adults in or near the fields of rapeseed or mustard where they develop and may move into a nearby crop almost on the day it comes up. Beetles first chew pits in the leaf surface; with further feeding, holes appear, then these may enlarge until the entire leaf is eaten or damaged so badly that it dries up. Eggs are laid in the soil and the developing grubs feed underground on the roots. A new generation of beetles will occur later in the season on full-grown rapeseed or mustard plants but damage at this time seldom occurs.

Prevent damage to seedlings by using either an insecticide applied on or with the seed, or by spraying the seedlings as soon as flea beetles invade the edge of the crop. Treating the outside 1 or 2 rods of the field usually is sufficient. (See Table II.)

Red Turnip Beetle (See Fig. 5)

These beetles are usually pests of seedling crops of rapeseed and mustard. The adult insects are about the size of Colorado potato beetles, but are red with three black stripes extending the length of the wings. The eggs are laid on the soil surface in the fall near the host plants and hatch in the spring. The dark-colored grubs feed on winter annual weed mustards, volunteer rapeseed, etc., and complete their development into adult beetles that move into seedling rapeseed crops. Invasions of red turnip beetles can be checked with foliage sprays. (See Table II.)

Beet Webworm (See Fig. 6)

The parent of the beet webworm is a medium-sized, light-brown moth that is partly active in the daytime. When numerous, the moths will often rise in large numbers from weed patches, especially stinkweed in bloom. The eggs are laid on the leaves of host plants. The caterpillars are dark green and marked with stripes and circles. Full-grown caterpillars are about an inch long. They are more slender and active than the bertha armyworm. The caterpillar enters the soil to spin a cocoon about 2 inches long, usually upright and just below the surface. It may pupate in this cocoon and complete its development without interruption to the moth stage, or it may hibernate there and pupate the following spring. There may be three flights of moths, the first with peak numbers about the middle of June, a further one about the middle of July, and a final one the middle of August. There are two main generations of caterpillars. The first appears about the end of June and the second the end of July. In flax fields they feed on foliage, but it has not been shown that they reduce flax yield. In rapeseed fields they may cause serious damage by devouring or peeling pods, stripping leaves, and removing bark from stems and branches. Sunflowers may be severely defoliated by webworms. Damage is often the result of an invasion, resulting from the caterpillars' habit of marching. In fully podded rapeseed fields damaged patches have an unnatural white look. The beet webworm is readily controlled with poison sprays. (See Table II.)

Bertha Armyworm (See Fig. 7)

The bertha armyworm is a serious pest of rapeseed, mustard, and flax but it may also attack legumes, many vegetables, and some weeds, such as lamb's quarters.

There are four stages in the life cycle. The adults are dark-colored night-flying moths with a wing spread of about 1½ inches. They occur most commonly from mid-June to mid-July but are seen only occasionally after dusk, feeding on flowers of the host plant. The eggs are laid in patches on the underside of the leaves, each female being capable of laying 400 or more eggs during her life.

About a week after being laid, the eggs hatch into tiny green caterpillars. The young worms feed on the leaves of the host plant but are seldom seen except on very careful examination.

When the worms are about 1 inch long, usually late in July or early August, they undergo a marked change in appearance and in feeding habits. From then to maturity the majority of the worms are a conspicuous velvety black, with a yellowish band along each side, while a few are dark brown with two rows of distinct black marks along the back. They also move up the plant to feed on the seed pods or bolls. The dark larvae are easily seen on the upper parts of the plants and infestations are usually first noticed at this time. The worms usually remain on the plants but a few hide on the ground under dead leaves and in cracks in the soil, especially during the heat of the day. Sometimes the worms will march out of a field in large numbers.

Damage may occur very quickly. In rapeseed or mustard the pods may be partially or wholly eaten, the surface layer may be chewed off the pod and seed development affected, and the green bark may be eaten off the stem; in flax the bolls may be eaten and large numbers may drop to the ground because of worms chewing through the larger branches.

When the worms reach full growth (about 1½ inches long), they stop feeding, burrow 2 to 5 inches into the soil and change to reddish-brown, torpedo-shaped pupae. These remain in the soil throughout the winter and following spring. The moths emerge from them starting about mid-June.

Fields should be examined for worms every few days after mid-July. Beat the foliage to knock the worms to the ground, then count the worms in a measured area. Do this several places in a field. If there are ten or more per square yard, spray immediately. (See Table II.) Large populations of the black worms can destroy a field quickly.

Grasshoppers and Cutworms

These general feeders can attack oilseed as well as cereal crops in the seedling stages. Flax, mustard, and rapeseed are more susceptible than cereal crops to cutworm damage. Control is the same as for cereal crops.

Flax Bollworm

The adult is a medium-sized moth that lays its eggs singly in the flax flowers between the developing boll and the petals. On hatching, the young caterpillar enters the boll and stays there until it has eaten all the seeds. Infested bolls turn brown prematurely. It then completes its growth by feeding on additional bolls, chewing a hole in the side of each new boll for this purpose. The caterpillar is green, with four white stripes. When full grown it goes into the soil to a depth of about 1½ inches, where it turns into a pupa and spends the winter. The moth flies in late June and early July. Outbreaks have occurred only at rather long intervals, but they can be serious in the flax-growing districts of West Central Saskatchewan. (See Table II.)

Diamondback Moth (See Fig. 8)

The moths are light-brown, slender insects about one-half of an inch long at rest. They make brief, low flights from plant to plant at dusk in rapeseed and mustard crops and will not usually be noticed. Diamondback caterpillars are dirty white to yellow at first, turning to green or partly green and partly dull red, and finally to pale green when full grown. The maximum length is not over one-half of an inch. They have the habit of moving rapidly backward with a lashing motion when disturbed, or of dropping off the leaf and hanging from a strand, which is spun as they drop. When full grown they pupate within a lacy cocoon spun anywhere on the plants; in heavy infestations, the cocoons will be readily noticed on the pods.

The caterpillars first feed on the leaves, normally from the lower side, and later eat parts of the young pods, or peel those that are beginning to fill. Seeds within damaged pods remain shrunken.

No stage of the diamondback can overwinter in Saskatchewan, so the infestation is re-established each year by moths immigrating on warm south winds. Generation time is 3 to 5 weeks, and there is time during the summer for about three generations, but only the one present in the larval stage the latter half of July is likely to be of any importance. The caterpillars are easily controlled with insecticides. (See Table II.)

Other Insects Common in Oilseed Crops

Several other insects may occur, especially in rapeseed. They have seldom appeared as pests in Saskatchewan. Two kinds commonly found are caterpillars of cabbage butterflies. The green, velvety one is the same as that nearly always found in garden cabbages; another, mauve and bright yellow, is from the closely related western cabbage butterfly. A few species of climbing cutworms are sometimes found in rapeseed fields. Some of these are not easily distinguished from green bertha armyworms. Aphids ("plant lice") are nearly always prevalent in rapeseed, both a grayish-green kind that clusters on the tops of the stems, and a green kind on the leaves and young pods. Occasionally, aphids become numerous in flax. Several insects are present that feed on the aphids; those most likely to be seen are the grubs and adults of several species of ladybird beetles.

INSECTS IN FARM-STORED GRAIN

Under some conditions insects are able to multiply rapidly in moist grain, causing it to heat. Grain that is uniformly dry will not spoil or become infested during the current crop year. The more common pests occurring in stored grain in Saskatchewan are rusty grain beetles, several kinds of fungus beetles, and mites.

Preventing Infestation

It is easier and cheaper to prevent infestations than to apply control measures. Always store new grain in clean, empty bins because new grain heats when placed on top of old grain. 1. Clean out, repair, and weatherproof empty granaries. 2. Spray the floors and inside walls with a bin spray containing malathion, or pyrenone. Apply the spray at least a week before binning new grain. 3. Harvest grain as dry as possible. 4. If grain has been binned tough, examine it carefully every 2 weeks for signs of insects and heating. Look for insects and mites by sieving samples from the surface and from probed depths. Use a 10-mesh sieve. Examine the sievings over slight heat to detect pests by their movement. Check for heating in the bin by feeling the surface with your hands. Thrust a metal pipe or rod into the grain to check for heating below the surface.

Storage pests will infest animal feeds also, and then invade stored grain. Therefore, empty feed bins should be cleaned thoroughly and sprayed with a bin spray before storing new feed.

Controlling Infestation

1. **Moving Grain in Winter**—Insect infestations usually can be controlled in cold weather by cooling the grain to 35°F or lower. Transfer infested grain to piles outside or to another granary. Several transfers may be necessary. Clean the grain during moving to remove as many insects as possible.

2. **Chemical Control**—Cythion is a special formulation of malathion for grain treatment. Do not use malathion unless labelled for use on grain.

a. **Dust**—Use 1 pound of 0.5 percent cythion per 10 bushels of grain.

b. **Spray**—Use one-half of a pint of 83.6 percent cythion in 2 to 5 gallons of water per 1,000 bushels of grain.

May be dusted or sprayed onto the grain as it passes through a grain auger, or onto the surface of the grain and mixed to control surface infestations. Fall or early winter treatment is the best. May not perform well under cool temperatures and is less effective if grain is damp, has dockage, or is heating.

Phosphine—Tablets, such as "Phostoxin" are placed in the grain in a grid pattern. Tablets release phosphine gas 2 to 24 hours after being exposed to air. A small percentage of the eggs of rusty grain beetle may survive treatment. A repeat treatment may be necessary after a period of 3 weeks if surviving eggs hatch. Treatment is not recommended when grain temperatures are below 40°F, in any portion of the grain to be treated.

Use 180 tablets per 1,000 pounds of grain.

Liquid Fumigants—Liquid fumigants are available. These can be poured on the surface or probed into the grain. Read and follow directions and warnings on the label.

Warning—When using grain protectant chemicals: a. Use extreme caution—never work alone; b. wear rubber gloves and wear a respirator with the proper cannister; c. follow label directions.

THE USE OF INSECTICIDES

Precautions in Handling Insecticides

Insecticides are poisons developed to kill insects. **Humans and animals can be accidentally poisoned by swallowing the insecticide, by eating insecticide-contaminated food, or by prolonged exposure to dusts and sprays.** Continued exposure to small quantities may not seem injurious at first but there may be less obvious cumulative effects.

The danger from the acute or immediate toxicity of the chlorinated hydrocarbons such as DDT is not high when they are used properly, although endrin is a hazardous chemical in this class. All these poisons are persistent and can accumulate in the fat of man and animals. Because of this, these insecticides are being replaced in many cases by the organo-phosphate and carbamate insecticides. Generally, these compounds are not very persistent but they may have a higher acute toxicity than DDT.

If blurred vision, headache, tightness of chest, or nausea are noticeable after exposure to insecticides, **call a physician at once or take the victim to a hospital immediately.** Be certain what insecticide was used. Take the label of the container to the doctor, as the antidote is listed on it.

If medical or hospital attention is not immediately available, call the Poison Control Centre in Regina, telephone number 522-1811 or in Saskatoon, telephone number 343-3111.

In the event of any delay in obtaining professional advice the following emergency treatments may be applied:

If the poison was swallowed, induce vomiting as quickly as possible. This can be done by giving 1 teaspoon of salt or ground mustard in a glass of warm water, or by sticking a finger down the throat. If poisoning is by BHC, lindane, chlordane, DDT, endrin or heptachlor, give hot coffee or tea containing 1 ounce of epsom salts **after the stomach has been emptied.**

If the poison was inhaled, move the patient into fresh air. If necessary, give artificial respiration.

The following precautions should be adhered to whenever insecticides are used:

1. **Read the label on the container.** This may save your life and prevent accident. It will name the product and its most effective use. It will also tell how to handle the material and what should be done in case of accident.

2. Wear clean, undamaged protective clothing, e.g., coveralls and rubber gloves. Special care should be exercised with concentrates. Respirators, with filter and cartridge recommended for the specific insecticide, and goggles should be worn for volatile materials or extremely toxic dusts or sprays. With daily exposure **(custom operators)** complete coverage with waterproof clothing is necessary.

3. Change contaminated clothing as soon as possible and wash before reuse.

4. If insecticides are spilled on the skin, wash immediately and thoroughly with soap and water, as some are absorbed through the skin.

5. While spraying or dusting, prolonged exposure should be avoided, sprays and dusts should not be inhaled, and smoking (especially hand-rolled cigarettes) should be avoided; all exposed parts of the body should be washed immediately afterwards.

6. Do not contaminate feed or water for livestock. Follow the rates of application shown on the labels, and **strictly observe the cautions with regard to the use of treated crops.**

7. Keep all pesticides in their original containers with proper labels. Store them in a safe place away from food or where food is handled. Keep them locked out of reach of small children, pets, or irresponsible persons.

8. Destroy all pesticide containers by burying or burning, and avoid smoke from such fires.

9. Equipment should be checked with water for leaks, clogged nozzles, etc., before use. Breakdowns during operation may involve repair work to equipment containing highly toxic material. Equipment (tanks, pumps, and booms) should be rinsed out and drained after use to prevent corrosion, rusting, or clogging. (See "Cross-contamination of Crops," page 105.)

10. Do not drain unused gallonage from sprayer tanks anywhere in farmyards. Do not drain sprayers near wells, sloughs, dugouts, or roadside ditches.

11. Do not mix different types or brands of livestock chemicals. The risk of poisoning from a mixture may be increased many times if certain chemicals are used in combination.

Formulations

Most insecticides are sold as formulated products in which other ingredients have been added to make them suitable for a variety of purposes.

Dusts should be applied dry in the concentration in which they are manufactured. They will not mix with water to make a spray.

Wettable powders mix with water but do not dissolve. They should be applied in sprays, except where they are stated to be suitable as dusts, i.e., warble powders. Generally, wettable powders contain a high concentration of the insecticide. If not diluted with water, they are expensive to use and may be dangerous to the animals treated or to animals feeding on treated foliage.

Emulsifiable concentrates mix with water to form a milky emulsion. Apply, only after dilution as directed, to either plants or animals. Do not use if the components have separated out because of freezing or other reasons and will not form a milky emulsion.

Oil solutions sold for domestic use in pressurized or other containers should not be applied to plants. Oil solutions should be applied to animals only in self-applicators (back rubbers) or, when recommended, as mist sprays.

Soluble powders such as methomyl (lannate) are applied in true solution. The solubility of methomyl in water is limited. Always use the recommended quantity of water.

Cautions on the Use of Insecticides on Crops

Insecticides and herbicides used carefully in the right place, in the right quantity, and at the right time are essential aids for farmers. However, they are poisonous and farmers should be aware of some of the less obvious hazards associated with their use.

Cross-Contamination of Crops—If a sprayer has been used to apply insecticides wash it out carefully with detergent and water. Failure to do so may lead to unwanted contamination of crops' sprayed subsequently. For similar reasons, a sprayer used to apply weedkiller should be cleaned in the following manner. First, carefully flush out tank, pump, and spray boom with detergent and water; then fill tank and system with a mixture of household ammonia and water (1 gallon to 100 gallons) and let stand for 24 hours; finally drain and flush with clean water.

Insecticide Residue Hazard—Many insecticides, notably the chlorinated hydrocarbons, dieldrin, aldrin, endrin, heptachlor, and DDT, are very persistent and may leave residues on crops or soils which could contaminate foodstuffs, including meat and dairy products. This contamination may occur in many ways which are not immediately obvious. For example, root crops such as carrots and potatoes grown in soil treated with these compounds in previous years may pick up detectable residues, or contaminated fodder may be unknowingly purchased. If cattle are fed on fodder containing even traces of a chlorinated hydrocarbon, it may be stored and concentrated and give rise to chemically detectable residues in meat and milk.

Insecticide Drift Hazard—With any method of application some of the insecticide may drift out of the treated field and contaminate areas nearby. Do not allow drift to contaminate streams, sloughs, vegetable gardens, pastures, or any crop likely to be used for livestock feed. Avoid spraying in more than a light breeze or when turbulent air is rising from hot ground.

Crops Used for Bee Pasture—Do not apply insecticides when the bees are foraging. Warn beekeepers before applying chemicals. Warn aerial sprayers away from apiaries.

INSECT PESTS OF LIVESTOCK AND POULTRY

Insecticide Application To Control Livestock Insects

Read "The Use of Insecticides" (page 104) and instructions on the label before using any insecticide. See Tables VI and VII for recommended chemicals for control of livestock and poultry insects.

Modern insecticides, properly used, will control most insects attacking livestock. Insect control will increase weight gains, grade of carcass, milk flow, and health of animals generally. It is essential for profitable livestock production in small farm herds as well as large ranch herds.

Satisfactory control can be obtained in small herds by hand-operated equipment but in large herds power equipment is essential.

Sprayers, to be suitable for control of livestock insects, must be capable of maintaining any pressure up to 500 pounds per square inch; they must be able to deliver at least 4 gallons per minute; they must be equipped with a mechanical agitator in the tank; they must have an adequate strainer between the tank and the pump, and proper drain cocks for draining pump and tank.

High pressures are necessary for livestock insecticides to penetrate the hair. The chemical must reach the skin to control warbles and lice and the scab must be broken to control warbles with rotenone. Universal-type sprayers are most suitable and are available at reasonable cost.

When using wettable powders in spray machines, special precautions should be taken to see that the pump is thoroughly washed after each use. Such materials should never be left in the tanks over night.

Single-nozzle, adjustable spray guns are most satisfactory for warble-fly control. Triple-nozzle spray guns are most suitable for spraying animals for louse control, barns, and other buildings for fly control, and farmsteads for mosquito control. Fan-type guns can be used for warbles, lice, and other livestock insects, particularly when using systemics. Most multiple-nozzle and fan-type guns are not adjustable. Pour-on insecticides are useful when power equipment is not available. They are especially valuable when weather conditions make the use of sprays undesirable.

Self-Applicators (back rubbers) for applying chemicals to livestock are very satisfactory for control of horn flies. They are of doubtful value in the control of other biting flies (horse flies, deer flies, mosquitoes, black flies, etc.). They have no value in the control of warbles.

Suitable applicators may be cheaply made with materials available on any farm. Several strands of barbed wire may be loosely twisted together and wrapped with old sacking, until a roll about 6 inches in diameter has been completed. This is then tied tightly every 4 to 6 inches with heavy cord. The roll may be attached to two posts a rod apart. It should be fastened 4 to 5 feet above the ground at the posts and be allowed to sag within a foot of the ground in the centre. Solutions suitable for use in applicators may be secured from most chemical companies. Do not use self-applicators for milking cows. Read the label on the insecticide container. This applicator will require about 1 to 1½ gallons of the mixture. It will be necessary to moisten it with additional chemical at about weekly intervals.

There are many other ways of making such a roll and other methods of attachment to posts. Any method which provides a suitable absorbent roll and allows the animals to treat themselves is satisfactory. The applicator should be located near the water supply, or salt block, or in any area where the cattle loaf.

If poisoning of livestock by insecticides is suspected call a veterinarian. Symptoms are in general similar for most animals; e.g., nervousness, wild stare, tremor, slobbering, diarrhea, loss of appetite and weight, paralysis and convulsions. Animals in poor condition are more susceptible to poisoning by livestock sprays than those in good condition.

Sanitation—Failure of insecticides to control certain insects, particularly house flies and stable flies, is often attributed to **resistance** of the insects to the insecticides. Such failures nearly always occur because of **lack of sanitation** and not because the insects have become resistant. If manure, litter, and other breeding substances are not cleaned up, the insects may appear in too large numbers for insecticides to control. **Sanitation is essential.**

Lice of Cattle

Blood-sucking lice are slate-blue when engorged and occur singly or in dense colonies on protected areas of the hide. Heavily infested animals will become thin, unthrifty, irritable, and dirty and will smell of stale blood. Loss of blood will cause anaemia and eventually death. The one variety of biting louse feeds on scurf and hair, rather than blood, and moves about freely, causing much irritation. The eggs or nits are pale yellow and attached to hairs. They hatch in about 15 days. Examine the skin surface for lice by parting the hair, especially in skin folds on the neck.

Beef cattle should be treated before entering a feed lot in the fall, as lice multiply rapidly during the winter. If spraying, use a high-pressure sprayer to thoroughly penetrate the dense hair and wet the skin over the entire body. Hidden surfaces along the underline require special attention. Pour-ons, washes, commercial dusts, or aerosol bombs are also available.

A few insecticides are available for use on dairy cattle. Some treatments can serve a dual purpose against cattle grubs and winter ticks as well as lice. If winter treatment is required, avoid chilling. In the spring, bulls and cows with suckling calves should be deloused before turning out to range. Certain "carrier" animals will remain infested during summer and should be marketed before they re-infest the rest of the herd.

Cattle Grubs

Usually noticed only as grubs in cysts or "warbles" on the backs of cattle (and occasionally horses, etc.) in the early spring from January to March. After 4 to 10 weeks in the cyst, the grubs crawl out through the breathing hole and drop to the ground to pupate. The adult flies are active on sunny days in May and June. Each female deposits 400 or more eggs on the hair of cattle and in doing so will often frighten the animals. The eggs hatch in 2 to 7 days and the larvae crawl down the hairs to penetrate the skin. After 7 to 9 months of wandering in an animal's body, and sometimes causing injury to internal organs, the larvae form cysts in the back and cut breathing holes through the skin. Besides a loss of condition, an animal may be damaged by an allergic reaction if a grub is broken in a cyst. Further losses occur upon slaughtering when grubby meats and hides are trimmed.

The flies do not fly far and will not readily cross water or other barriers. Hence local control, and particularly community control, can have lasting results. Generally, a systemic insecticide is used in the fall, soon after September 15 and often in conjunction with louse control. Formulations for sprays, pour-ons, and dusts are available. In a small herd or particularly in dairy animals the grubs may be removed from the cysts by hand or a rotenone dust or wash may be applied directly to the grubs in the cysts.

Ticks

Three varieties commonly occur in Saskatchewan. The winter tick completes its life cycle in 1 year, spending the winter on horses, deer, and moose. Heavily infested animals become thin and may die.

There are two varieties of spring tick in the southern half of the province. These have a 2-year life cycle. They feed the first summer on rabbits and gophers and the second on cattle, dogs, and man. They get on animals in May and June by climbing to the tips of twigs and grasses along pathways to wait for an animal to pass. They feed painlessly for about a week before dropping off to lay eggs. Occasionally a single tick can cause temporary ascending paralysis and death unless removed. Several diseases can be transmitted.

Keep animals off tick-infested areas in May and June. Several insecticides are available for use on animals. Brush away individual ticks with light oil. Treat clothing with mosquito repellents.

Sheep Ked (Sometimes misnamed sheep tick)

This is a wingless, blood-sucking fly that spends its entire life on sheep and occasionally goats. Shearing removes many keds but a steady increase, especially on underfed range animals during the winter, causes blood losses that affect the animals by mid-winter.

Spray, dip, or dust the entire flock, preferably a week or two after shearing when cuts are healed. Do not miss any animals. Treat all new stock brought in, because a single infected animal will infect the entire flock.

Horn Fly

A small blood-sucking fly, about half the size of a house fly. In June to September it is often seen in dense clusters around the horns and on the backs of cattle. Bulls are heavily attacked. The eggs are laid in fresh manure where the larvae and pupae develop. The entire life cycle is completed in 2 to 3 weeks. They constantly irritate the animals, reducing milk yields by as much as 20 percent, and beef gains by a half pound a day.

Insecticides may be applied by spraying, dusting, or with a back rubber.

Stable Fly (Biting house fly)

Resembles the house fly very closely but stings and sucks blood. In wet years in July and August it can be one of the worst insect pests of all farm animals and of man. The eggs are laid and the larvae develop in wet, fermenting hay or straw and there can be several generations per summer.

It is important to spread and dry out wet hay and straw piles. Some relief may be obtained by spraying animals with recommended insecticides.

Face Fly

This close relative of the house fly appeared in Nova Scotia in 1952 and has now extended its range westwards into the treed areas of Southeastern Saskatchewan. It tends to cluster on the faces of cattle, especially in August, feeding around the eyes and muzzle. It is so irritating that about 20 flies are sufficient to interrupt grazing. It is capable, like the house fly, of transmitting pink eye. The eggs are laid in fresh cow manure and in warm weather new adults emerge in 2 weeks. The adults overwinter in buildings, sometimes in large numbers.

Control by spraying the back, sides, shoulders, neck, and face with approved insecticides at about weekly intervals in July and August.

House Fly

A common irritating pest on animals out of doors and in buildings. Proved capable of transmitting many diseases and parasites. The maggots develop in manure and decaying materials. One ton of manure can produce more than 2½ million flies every 2 weeks.

Control is impossible without first spreading out and drying manure and garbage. Then, if necessary, spray barn interiors with the appropriate insecticide. (Note special precautions on labels for dairy barns, piggeries, etc.) Impregnated cords and grids, poison baits, and space sprays are also available.

Mosquitoes

Breed mainly in temporary, grassy pasture sloughs and roadside ditches, newly flooded with snow, rain, or irrigation water. Our species do not breed in large permanent sloughs or dugouts. The eggs are laid on water or damp soil. Most species overwinter as eggs and must be dried and frozen before they will hatch. The larvae or "wigglers" must have water to survive and can complete their development in as short a time as 1 week. To detect them dip up the water in a white dipper. During the day the adults rest in grass and low bushes unless disturbed.

Certain species of mosquitoes transmit the virus of encephalitis which causes "sleeping sickness" in horses. This virus can also infect man.

A properly planned, community-wide abatement program can be very effective. Begin by draining breeding places or applying approved larvicides. Residual sprays may be applied to adult resting sites. Thermal fogs give immediate but temporary relief.

Black Flies

Small, grayish, stout, hump-backed flies that attack animals, poultry, and man for blood, mainly in May or June (later in the north). They are not to be confused with the larger horn fly which appears in the hot part of the summer and lives continuously on animals. Black flies develop only in flowing water. In certain years one species emerges from the Saskatchewan River in enormous numbers for a few days and swarms are carried by warm, steady winds for many miles. All animals are attacked, but bulls and milking cows are particularly susceptible to damage. A few hours after a mass attack the animals become sick, develop large swellings along the underline, and may die. Black flies emerging from the smaller rivers are sometimes abundant enough in valley pastures to reduce weight gains and milk or egg production. Other species sometimes transmit bird malarias to turkeys and ducks. If black flies are suspected, send specimens to your agricultural representative.

Control is a specialist's job but some relief for animals can be obtained with livestock sprays. In areas within 50 miles of the Saskatchewan River, valuable animals and especially bulls should be stabled at the first signs of a black fly attack. Smudges offer some protection. Repellents are effective for man.

Horse Flies and Deer Flies

These are the largest of the blood-sucking flies. The larvae develop in wet soil. Horse flies sometimes emerge in large numbers and prevent animals from grazing. There is some danger of infections from the bites.

Drain breeding sites and provide darkened shelters or use livestock insecticides.

Horse Bots or Nose Flies

These flies resemble bees but do not sting. They hover under horses, annoying and frightening them by darting in to attach eggs to the hairs of the muzzle, throat, and legs. The larvae burrow into the mucous membranes of the mouth and eventually attach themselves to the walls of the stomach and intestines, causing unthriftiness and even death.

Chemicals are available for control of the larvae.

Lice of Sheep, Goats, and Hogs

Each species of louse can develop on only one kind of animal. Thus cattle lice cannot live on hogs, etc. Lice may be expected on any animal showing a rash, loss of hair or wool, poor condition, etc.

Insecticides are available but avoid chilling animals or sun-scalding hogs as a result of the treatment. Rotenone is poisonous to hogs.

Mange and Scab Mites

These mites may attack horses, cattle, swine, and sheep. Irritation causes animals to rub and scratch. The mites are much smaller than lice and thus are often detected only upon loss of hair or by scab formation.

Infections on horses, cattle, or sheep must be reported to the Health of Animals Branch immediately.

Spray with insecticide and clean up infected premises.

Fleas of Animals and Birds

These are shiny, brown, jumping insects commonly infesting cats, dogs, and small mammals. Some species infest chickens and birds. The larvae are up to one-quarter inch long and feed on debris in the bedding of animals and in cracks in the floor, etc. Development from eggs to adults requires from 2 weeks to several months. They often attack man, causing a painful bite characterized by a small central red spot and little swelling. Thoroughly clean the sleeping quarters of dogs and cats, as well as carpets and floors. Use commercially available insecticides as recommended on the container.

Lice of Poultry

There are several species but all spend their entire life cycle on chickens, ducks, turkeys, etc. They can live for only a few days away from chickens and for only a day or so on man. Infested chickens are listless and their egg production declines.

Dust birds and premises with a recommended insecticide.

Mites of Poultry

Chickens are generally infested with one or more of four common varieties of mite, especially in warm weather. The common red or roost mites live in roosts, nest boxes, etc., and attack the chickens only at night. They can live 4 or 5 months without food even in the coldest weather. They will sometimes attack other birds, man, and animals and are thus transferred to new premises. Birds nesting in a house sometimes leave chicken mites behind and these can migrate down through a house, causing humans much irritation. Northern fowl mites live continuously on the bird, as do scaly-leg mites, which burrow under the scales causing them to thicken. Depluming mites also burrow into the skin, causing the birds to pull out feathers because of irritation.

Treat with sprays or dusts as recommended.

Insecticides should be used only for the purposes recommended on the label and the label instructions should be followed to the letter. Since these recommendations are based on many careful experiments they represent the best compromise for effective control, economy, and safety. Anyone using insecticides frequently or in large quantities is advised to get a copy of the **Pesticide Safety Handbook** (price $1.00) published by the Canadian Agricultural Chemicals Association, Suite 1004, 1010 St. Catherine Street West, Montreal 2, Quebec.

REFERENCES

Canada Department of Agriculture

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Ticks Affecting Man and Dogs in Canada. Publ. 1446.
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Saskatchewan Department of Agriculture

Chemical Control of Insects in Gardens, Yards and Shelterbelts. Publ. 625.
Insect Control on Field Crops in Saskatchewan. Publ. 622.
Mosquito Control. Publ. 673.

TABLE I
Insects of Farm-stored Grain

Insect	Description and Damage	Control
RUSTY GRAIN BEETLE	A flat, reddish-brown beetle about 1/16 in. long. Can move quickly in warm grain. Larvae chew into germ end of kernels where they feed and complete their development. Antennae are threadlike, not clubbed at tip. Can live in very dry grain.	Move grain in cold weather and dry if necessary. Chemical control.
FOREIGN GRAIN BEETLE (A Fungus Beetle)	A reddish-brown beetle about 1/16 in. long. Feeds on moldy grain which contains a large amount of dockage. Antennae are clubbed (enlarged) at tip. Indicate tough or damp condition in grain.	Dry the grain. Chemical control.
RED FLOUR BEETLE and **CONFUSED FLOUR BEETLE**	Reddish brown, about 1/8 in. long. Larvae feed on germ of kernel and in grain dust, flour, and feed. Associated with heating grain.	Dry the grain. Chemical control.
SAW-TOOTHED GRAIN BEETLE	Dark-brown adults about 1/8 in. long. Larvae feed on germ of wheat kernels. Adults and larvae feed on grain dust. Edge of thorax shows "saw teeth" when magnified.	Chemical control.
MEAL MOTH	Adult moth forewings are dark brown at tip and base, with gray in between. Cream-colored larvae with black head which web kernels together and form cocoons inside the cluster, usually only in tough grain.	If webs are confined to surface, rake off and burn. Dry grain if necessary.
MITES	Grain mites feed mostly on germ of kernel. Longhaired mites feed on grain and dockage. Give a strong "minty" odor to grain.	Move grain and dry if necessary.
GRANARY WEEVIL	Dark brown, about 1/8 in. long with a distinctive snout. Female chews hole in side of kernel, deposits egg, and seals hole. Insect develops from egg to adult inside kernel.	Rake off rafts of insects from grain and burn.
HAIRY SPIDER BEETLE	Adult dark brown about 1/8 in. long with spiderlike legs. Seldom occur in sufficient numbers to cause damage.	Control not usually necessary.

TABLE II*
Insect Pests of Field Crops
See "The Use of Insecticides," page 104. After 1972, see 1973 and later revisions of Saskatchewan Department of Agriculture Publication 622 for insecticide recommendations

Crop	Symptoms and Damage	Likely Insect	Control
WHEAT, OATS, BARLEY, RYE	Patchy stand; planted kernels bored into, or germ end eaten away; stems shredded below ground; dead seedlings in drill row, or centre leaf dead and outer leaves green. (See page 100.)	**WIREWORM**—slender, hard-bodied, shiny, yellow worms in soil, do not curl up when disturbed.	Treat seed with insecticide seed dressings at rate recommended on the label.
	Thinning of seedling stand; young plants cut off at or below soil surface; tops disappear leaving only stubs underground. (See page 101.)	**PALE WESTERN CUTWORM** — pale-gray, soft-bodied worm in soil; curls up when disturbed; mainly in Prairie area.	Spray with 2 oz/ac active endrin on young cutworms in moist soil; 4 oz in dry soil or on older cutworms.
		RED-BACKED CUTWORM — dark-gray worm with dull, reddish stripes on back; mainly in Parkland area.	Spray with insecticide as for pale western cutworm.
		ARMY CUTWORM — dark olive-green with two rows of indistinct creamy spots or a dull yellowish-brown band along back; overwinters as partly grown larva; often on soil surface in evening or on cloudy days; mainly in southwest.	Before seeding or if crop not emerging as expected, examine field for larvae. If necessary, delay seeding or spray with insecticide as for pale western cutworm.
	Seedling crops on summerfallow or stubble destroyed from edges inward, by invading hoppers; seedling crops on stubble destroyed by hoppers hatching right in field; plants in shot blade stripped; head clipping in ripening crops. (See page 101.)	**GRASSHOPPERS**	Read the grasshopper forecast. Practise cultural control where serious infestations exist. (See page 101.) Be prepared to spray the hoppers after hatching begins, using carbaryl (Sevin) at 10 oz, dimethoate at 3 oz, or malathion at 12 oz/ac active insecticide. Carbaryl prior to 14 days, dimethoate prior to 21 days, malathion prior to 7 days of harvest.
	Late-seeded spring grains or seedlings of fall rye or winter wheat turn brown and die; plants covered with small, green insects.	**GREENBUG**—small, green plant lice or aphids that suck plant juices.	Spray with dimethoate, 3 oz active/ac, if registered for this purpose, malathion at 10 oz active/ac, or at 3 oz active/ac.
	Late-seeded barley turns brown and dies; plants covered with small, green insects and sticky liquid (honeydew).	**CORN LEAF APHID** — small, green, soft plant lice.	Spray with insecticide, same as for greenbug. Not necessary after boot stage.
	Heads and stems of cereals from mid-dough stage to harvest may be covered with clusters of tiny aphids; no evidence of damage.	**ENGLISH GRAIN APHID** — small, green, yellow, or pink plant lice.	Insecticide sprays effective but usually not necessary.
	Central shoot withered; tiny, whitish maggots or "flaxseeds" between stem and base of leaves; stems of mature plants bent just above lowest joint.	**HESSIAN FLY**	No satisfactory control; control usually not necessary.
	Leaves eaten; heads cut off; damage may continue after crop is cut; mostly in eastern half of province, occasionally in other parts.	**ARMYWORM**—large, dark greenish-brown worm with stripes down sides; worms hide by day and feed afternoon and evening; sometimes move in armies.	Spray with 20 oz/ac active malathion.
	Stems of ripe wheat girdled inside; broken off evenly at soil surface; "sawdust" in stems. (See page 102.)	**WHEAT STEM SAWFLY**—slender, wasp-like adults lay eggs inside wheat stems; eggs hatch and grubs girdle stem.	Use resistant crops and cultural methods. (See page 102.)
FLAX	Thinning of seedling stand; young plants cut off at or below soil surface; tops disappear, leaving only stubs.	**CUTWORMS** (See page 101.)	See under cereal crops above.
	Leaves, flowers, bolls eaten or cut off in July and August.	**BERTHA ARMYWORM** — young worms, green and inconspicuous on plants; older worms green to velvety black and easily seen on plants. (See page 103.)	No registered insecticidal treatment. Consult your agricultural representative or other reliable source.
	Infested bolls turn brown before ripe. Bolls either with small worm inside or empty with all seeds eaten and round hole in the side.	**FLAX BOLL WORM** — green worm with four white stripes, bores into boll, eats seeds, leaves boll, and feeds on other bolls from outside.	No registered insecticidal treatment. Consult your agricultural representative or other reliable source.

*Abbreviations used in the tables are as follows: E.C. – Emulsifiable Concentrate; S.P. – Soluble Powder or Sprayable Powder; W.P. – Wettable Powder; tsp – teaspoon; tbsp – tablespoon; gal – gallon; oz – ounces; lb – pound.

Crop	Symptoms and Damage	Likely Insect	Control
FLAX	Leaves and flowers eaten; patches of bark eaten off stems and branches. Worms also feed on lamb's quarters and Russian thistle and may migrate from weedy fields into crops. Do not feed on grains or grasses. Outbreaks occur in July or August.	**BEET WEBWORM** — slim, lively worms, dark green with black lines and circles.	Spray with trichlorfon (Dylox) at 6 oz active insecticide/ac (not after flowering).
	Leaves covered with tiny green aphids and some sticky liquid (honeydew) in late July and August.	**POTATO APHID**	Insecticide sprays effective but usually not necessary.
RAPESEED and MUSTARD	Seedling plants cut off and devoured.	**CUTWORMS** (See page 101.)	See under cereal crops above.
	Seedling leaves pitted with holes, margins scalloped, or leaves wholly destroyed. Damage usually seen at crop margins following invasion from stubble fields of preceding year's rapeseed or mustard crop.	**FLEA BEETLES**—shiny beetles about 1/12 in. long; usually black. Jump off plants quickly when disturbed.	Treat seed with commercially prepared insecticide seed dressing; or spray beetles with DDT at 10 oz active/ac; or malathion at 8 oz active/ac; or azinphos-methyl (Guthion) at 1 oz active/ac.
		RED TURNIP BEETLE—dark red beetles, 3/8 in long. Three black stripes running lengthwise down back.	Spray with DDT at 10 oz active/ac in seedling stage.
	Young and maturing pods peeled or partially or wholly devoured; patches of bark eaten off stems and branches; leaves damaged in heavy infestations. Badly affected patches of crop look dirty white.	**DIAMONDBACK MOTH** — light-green to pale-yellowish, spindle-shaped larvae, up to ½ in. long. Wriggle rapidly backward with a whipping motion when disturbed or drop quickly on a spun silken thread. (See page 103.)	Spray with malathion or azinphos-methyl (Guthion) at 5 oz active/ac; or trichlorfon (Dylox) at 16 oz active/ac. Do not apply malathion within 7 days, azinphos-methyl within 30 days, or trichlorfon within 21 days of harvest.
		BERTHA ARMYWORM— (See under Flax.)	Spray with methomyl (Lannate) at 3-4 oz active insecticide in at least 1 gal water/ac.
		BEET WEBWORM— (See under Flax.)	Spray with 6 oz active trichlorfon/ac prior to 21 days before harvest.
ALFALFA-GRASS MIXTURES, HAY FIELDS, and PASTURES	Leaves and stems partly or completely eaten.	**GRASSHOPPERS**	Spray with 10 oz/ac of active carbaryl (Sevin), or 12 oz/ac of malathion, or 3 oz/ac of dimethoate. Carbaryl or malathion treated pastures may be grazed immediately after spraying; dimethoate after 2 days.
ALFALFA for seed	Buds "blasted," turn silver gray; crop does not flower well; flowers drop off too soon; plants look spindly and stunted; many brown, shrivelled seeds at harvest.	**PLANT BUGS**—lygus, alfalfa plant bug, and Plagiognathus.	Thoroughly burn stubble and straw in early spring. This destroys eggs of alfalfa plant bug and Plagiognathus. Spray trichlorfon or dimethoate at 8 oz active/ac.
SWEET-CLOVER for Hay, Silage, Seed, or Soil Improvement	Seedlings eaten off above ground as soon as they come up; crescent-shaped and jagged notches in leaves due to insect feeding.	**SWEETCLOVER WEEVIL** — small, dark-gray, snout beetles; drop to ground when disturbed and difficult to see.	Seed new stands as far away as possible from second-year stands; cultivate stands as soon as hay or silage crop is removed. Insecticide spray treatment to seedling stands in spring using azinphos-methyl (Guthion) at 6 oz, or carbaryl (Sevin) at 16 oz active/ac; to first-year clover in the fall, apply malathion at 10 oz active/ac.

For further information on these or other insect pests of field crops, write to the Pest Control Specialist, Saskatchewan Department of Agriculture, Regina, or the Entomology Section, Canada Department of Agriculture Research Station, Saskatoon.
Send sample of insects and damaged plants.

TABLE III*
INSECT PESTS OF VEGETABLES
Before using any insecticides read "The Use of Insecticides" (page 104) in this section.
After 1972, see 1973 and later revision of Saskatchewan Department of Agriculture publication 625 for insecticide recommendations.

Insect	Plants Attacked	Description: Injury, Pest, Season of Attack	Chemical Control and Methods of Application
ANTS	Plants not eaten.	Make holes and mounds in soil, invade houses. Throughout growing season.	Treat soil surface in infested areas with chlordane or carbaryl (Sevin) as directed on the label. Do not apply directly on vegetables or fruits.
APHIDS Plant lice	Peas, potatoes, etc.	Leaves deformed, curled, discolored, by tiny, soft, sucking insects which cluster on the undersurface of the leaves, tips of twigs, seed pods, etc. Leaves may drop. Late spring and summer.	Malathion 50% E.C. 1 tsp per gal water. Apply spray forcefully to leaves. Repeat as needed. On potatoes, commercial growers can use dimethoate at 4 oz active ingredient or oxydematonmethyl at 8 oz active ingredient/ac.
BEET WEBWORM (incorrectly called armyworm)	Garden plants, pigweed, Russian thistle, etc.	Plants quickly eaten by slim, small, active caterpillars, green, marked with fine black lines and circles. Outbreaks occur in early July or in August. Armies migrate from weeds when these dry up or are eaten.	To prevent invasion of gardens, destroy all surrounding weeds in early June, spray weeds with trichlorfon (Dylox), 80% S.P. 1 tsp per gal water. In gardens use same chemical treatment. If necessary to treat edible parts of plants within 28 days of harvest, use only pyrethrum or derris.
BLISTER BEETLES	Broadbeans, onions, potatoes, beets.	Blossoms and leaves eaten by large, soft, active beetles, blue bronze, black, gray, or spotted. Appear suddenly, often in large swarms, May to August.	On edible parts of plants dust beetles with derris or pyrethrum (see label). On shrubs or potatoes use malathion or diazinon 50% E.C. 1 tsp or carbaryl (Sevin) 50% W.P. 2 tbsp/gal water.
CABBAGE WORM	Cabbage, cauliflower, turnips.	Large, circular holes eaten in leaves and hearts of plants by green caterpillars. Masses of soft, green pellets. Eggs laid on leaves by large, white butterflies. Throughout summer.	Dust plants with derris, pyrethrum, or endosulfan (Thiodan) or spray with endosulfan 50% W.P. 1 tbsp/gal water. Commercial growers can use methomyl (lannate) at 4-8 oz/ac. Within 7 days of harvest, use only derris or pyrethrum.
CUTWORMS	All garden crops.	Stems cut off at ground level by dull-colored, fleshy caterpillars which curl up when disturbed. Feed by night, hiding in soil by day. May and June. Eggs laid in soil previous fall.	In home gardens only, dust soil surface with chlordane or diazinon. Do not apply directly on vegetables. Do not feed vegetables or culls from treated areas to livestock.
EUROPEAN CORN BORER	Sweet corn.	Tassels broken over, ears and stems tunnelled. Worms up to 1 in. long, dirty white or pinkish with black head. Egg masses on lower surfaces of leaves. Mid-July to mid-August.	Carbaryl (Sevin) 50% W.P. 5 tbsp/gal water (4 lb in 40 gal/ac). Three treatments at 5-day intervals are recommended, the first in late July when eggs begin to hatch.
FLEA BEETLES	Cabbage, turnip, radish, potatoes, etc.	Small, round holes eaten in leaves by tiny, quick-jumping black beetles. Early seedlings may be destroyed. Present in spring until July and again from August onwards.	Dust with derris or spray with malathion, diazinon or endosulfan as soon as beetles appear. Keep close watch on seedlings and transplants to prevent damage. Within 7 days of harvest, use only derris.
GRASSHOPPERS	All garden crops.	Seedlings and mature plants eaten quickly by young hoppers or adults.	Spray in and around garden with malathion 50% E.C. 1 tsp/gal water (24 fl oz/ac in water) or carbaryl (Sevin) 80% S.P. 2 tbsp/gal water (¾ lb/ac in water).
ONION MAGGOT	Onions.	Seedlings wilt and die. Roots and lower stems tunnelled by small, white, legless maggots. Infested onions rot. Adults similar to houseflies lay tiny, white, elongated eggs around plants. First generation late May to early June, second generation mid-to-late July. Worst in June.	Apply diazinon spray or granular material to rows when onions are emerging. Follow rates on label. For market gardens apply dasanit, diazinon, ethion, or dyfonate granules in the furrow using a positive feed Gandy-type applicator. Granules must be applied above or close to seed but not touching it. For green bunching onions, use only diazinon or ethion.

*Abbreviations used in the tables are as follows: E.C. – Emulsifiable Concentrate; S.P. – Soluble Powder or Sprayable Powder; W.P. – Wettable Powder; tsp – teaspoon; tbsp – tablespoon; gal – gallon; oz – ounces; lb – pound.

Insect	Plants Attacked	Description: Injury, Pest, Season of Attack	Chemical Control and Methods of Application
POTATO BEETLE	Potatoes, wild tomato, egg plant.	Foliage eaten by round-backed, yellow beetles with ten black stripes, and by fat reddish grubs. Throughout summer.	Dust plants with derris or dust or spray with azinphos-methyl, carbaryl, carbofuran, endosulfan (Thiodan) or diazinon as directed on container as soon as beetles or grubs appear on plants. Guthion may be used on larger acreages. Do not feed treated vegetables or culls to livestock.
SLUGS	Most garden plants.	Gray to grayish-brown, up to 2 in. long, resemble snail without shell. Move slowly and leave glistening trail from body secretion. Hide in dampness under debris in day. Feed at night on foliage and fruits. Throughout summer.	Use metaldehyde liquid, dust, or bait. Poisoned slugs may live for several days but soon stop feeding and eventually die. Do not apply to edible parts of plants. Slugs hide under boards placed in gardens and may be baited there or collected daily and destroyed.
TURNIP MAGGOT	Rutabaga, cabbage, cauliflower, radish.	Root surface and flesh grooved by maggots. Young plants killed, older plants wilted. Adults, eggs, and maggots similar to those of onion maggot. Egg-laying begins early in mid-July and continues to end of August.	Diazinon 5% granular in row at time of seeding, 2 oz/100 ft of row or diazinon spray as directed on label. Commercial growers can use fensulfothion, chlorfenvinphos, or carbofuran as directed on label.
WIREWORMS	Potatoes, lettuce, corn, onions, carrots, and other plants.	Seedlings wilt and die from underground boring by slender, hard-bodied, shiny, yellow worms. Seeds and sprouts destroyed. Potato tubers, carrots, etc., tunnelled.	In spring or fall treat the soil surface with chlordane 25% granular 1 lb/1,000 sq ft. Immediately work into the top 4 in. or 5 in. of soil. Crops grown in treated soil must not be fed to livestock. Do not apply more than once in 4 years. On field potatoes, use chlordane 10 lb or dyfonate 5 lb/ac.

For further information, write to Pest Control Specialist, Saskatchewan Department of Agriculture, Regina, or to Entomology Section, Canada Department of Agriculture Research Station, Saskatoon.
Send samples of insects and damaged plants.

TABLE IV*
INSECT PESTS OF ORNAMENTALS AND FRUITS
Before using any insecticides read "The Use of Insecticides" (page 104) in this section.
After 1972, see 1973 and later revision of Saskatchewan Department of Agriculture publication 625 for insecticide recommendations.

Insect	Plants Attacked	Description: Injury, Pest, Season of Attack	Chemical Control and Methods of Application*
ANTS	Plants not eaten. Feed on sweets.	Make holes and mounds in soil; invade houses. Often indicate presence of aphids. Throughout growing season.	Treat soil surface in infested areas with chlordane or carbaryl (Sevin) as directed on the label. Do not apply directly on vegetables or fruits.
APHIDS (Plant Lice) (Also See Table V)	Fruit trees, ornamental shrubs, flowers.	Leaves curled or discolored by small soft insects which cluster on the trunk, branches, leaves, or seed pods. Aphids inside curled leaves are very difficult to control with contact sprays. Throughout summer.	Spray insects with malathion 50% E.C. 1 tsp/gal water. Check label for interval required from last spray to harvest. Use dimethoate as a soil drench, a bark paint, or a foliage application to poison sap (see label and see aphids in Table V).
GLADIOLUS THRIPS	Gladiolus.	Silvery blotches on leaves and blasted blooms in summer, small, dark pits on corms in winter. Adults quick moving, tiny, slender with four long, narrow, hairy wings. Young wingless. Pest overwinters only on corms in storage.	Corm treatment: In fall dust thoroughly with carbaryl, store in open containers. Plant treatment: four applications of diazinon, dimethoate, or malathion dust or spray as directed on the label beginning when plants are 10 in. high.
GLASSY CUTWORM	Lawns.	Dead brown spots caused by greenish-white, translucent worm up to 1 ½ in. long with red-brown head. Feed on roots and lower stems. Spring to July.	Spray lawn with diazinon 1 oz active/1,000 sq ft (8 oz of 12.5% E.C./gal water). Water well immediately after application.
SOD WEBWORM	Lawns.	Dead, brown spots caused by short, bristly, active, dark-gray worms with black spots; in silk-lined tunnels in turf. Spring to July.	
GRAPE LEAF-HOPPER	Virginia creeper, grape; shrubs and flowers when creeper defoliated.	Yellow spotting and drying of leaves with damage developing from the ground upwards. Very small, yellowish sucking insects, immature stage wingless on undersurface of leaves; mature stage winged very active. Spring and summer.	Spray with dimethoate, 1 tbsp 2E/gal water.
ROSE CIRCULIO	Roses.	Buds and flowers ruined by holes, bored by small, red and black snout beetles. Mid-June to mid-July.	Hand pick the beetles; no satisfactory chemical control.
CANKERWORMS	Manitoba maple, elm, ash, fruit trees.	Small holes appear in leaves; later foliage is completely eaten by brownish-green caterpillars which spin silken threads. May and June.	Spray trees as soon as damage appears with malathion 50% E.C. 1 tsp/gal water. Check label for interval required between last spray and harvest.
CURRANT FRUIT FLY	Currants, gooseberries.	Infested fruit ripens and drops prematurely. Fly inserts eggs into immature berry where tiny white maggot develops.	Spray bushes until they drip with methoxychlor 25% W.P. 2 tbsp/gal water or malathion or diazinon when 80% of blossoms have withered and fallen, and again 10 days later.
IMPORTED CURRANT WORM	Currants, gooseberries.	Leaves devoured by green, spotted caterpillars. Appear with first leaves and occur throughout summer.	Spray foliage with diazinon 12.5% 2 tbsp/gal. Water as soon as leaves are well formed. Repeat as needed. After fruit appears use derris or pyrethrum.
MITES	Currants, raspberries, strawberries, etc.	Leaves turn brown and dry up. Undersurface of leaves covered by very fine, silken web. Pest almost too small to be seen. Most troublesome in dry years. June onwards.	Spray all leaf surfaces with dicofol (Kelthane) 18½% W.P. 2 tsp/gal water or malathion 50% E.C. 1.5 tsp/gal water. Apply first when leaves appear and repeat just before blossoms open.
RASPBERRY CROWN BORER	Raspberries, loganberries.	Canes lack vigor and yield poorly; white caterpillar with brown head burrows in crown roots.	Mix 2 tbsp diazinon 12.5% in 1 gal water. Apply 1 pint/crown in October or early spring.
RASPBERRY FRUITWORM	Raspberries, loganberries, etc.	Blossom clusters skeletonized and holes eaten in early buds by tiny, oval, yellowish-brown beetles. Fruit infested with tiny, yellowish-white grubs.	Spray plants until they drip with diazinon 12.5% 2 tbsp or malathion 50% 1 tsp/gal water. Apply when blossom buds begin to separate but before blossoms open.
RASPBERRY SAWFLY	Raspberries, loganberries.	Early leaves eaten from edges inward; mature leaves with irregular holes, or skeletonized. Spiny, pale-green larvae ½ in. long. Occur with first leaves through to fruiting.	Spray foliage with diazinon 12.5% 2 tbsp/gal water, when blossom buds begin to separate and again immediately before blossoms open, or dust with 1% rotenone.
PRAIRIE TENT CATERPILLAR	Rose, gooseberry, cherry, apple, etc.	Leaves eaten in May and June by dark, hairy caterpillars that construct conspicuous tents of white silk.	Spray caterpillars with malathion 50% E.C. 1 tsp or carbaryl (Sevin) 50% W.P. 1 tbsp/gal water.
PEAR SLUG (A Sawfly larva)	Cotoneaster, Mountain ash, Prunus.	Slimy, dark-green or almost black larvae, about ½ in. long when full grown. Browns the foliage. Late summer and fall.	Treat with malathion 50% E.C. 4 tsp/gal water or apply rotenone 1% dust.

For further information write to Pest Control Specialist, Saskatchewan Department of Agriculture, Regina, or to Entomology Section, Canada Department of Agriculture Research Station, Saskatoon.

*Abbreviations used in the tables are as follows: E.C. – Emulsifiable Concentrate; S.P. – Soluble Powder or Sprayable Powder; W.P. – Wettable Powder; tsp – teaspoon; tbsp – tablespoon; gal – gallon; oz – ounces; lb – pound.

TABLE V*

INSECT PESTS OF SHELTERBELTS AND SHADE TREES

Insect	Plants Attacked	Description: Injury, Pest, Season of Attack	Chemical Control and Methods of Application*
APHIDS (Plant lice)	Spruce, pine, larch, balsam.	Clusters of soft, brown, green, or black insects on the trunks, branches, twigs, or needles. Several generations a year.	Spray leaf and needle surfaces with one of the following: malathion 50 E.C. at 1 tsp/gal water; meta-systox-R 25 E.C. at 2 tsps/gal water; or Cygon 2E or 4E as per label instructions. Apply when insects seen or first damage noted.
	Caragana, maple, elm, ash, poplar.	Leaves curled or discolored. Clusters of soft insects on trunks, branches, leaves, or seed pods. Several generations a year.	
BIRCH LEAF MINER	Birch.	Larvae feed between the upper and lower surfaces of the leaves producing blotches or blisters. Attack occurs in June.	Spray foliage with diazinon 50 E.C. at 1 tsp/gal water; or malathion 50 E.C. at 2 tsp/gal water; or use Cygon 2E or 4E as per label instructions. Apply when first damage noted.
BLISTER BEETLES	Caragana, ash, lilac, honeysuckle.	Blossoms and leaves devoured by swarms of large, active, purple, blue, green, gray, or black beetles in June and early July.	Spray leaves with malathion 50 E.C. at 1 tsp/gal water; diazinon 50 E.C. at 1 tsp/gal water; or carbaryl (Sevin 85 S.P.) at 3 tsp/gal water. Apply when adult beetles seen.
BORERS	Ash, poplar, Mountain ash, elm, pine, spruce.	Holes occur in stems and branches; whitish grubs burrowing in wood. Trees are weakened and may ultimately die.	Inject carbon tetrachloride or carbon bisulfide into burrows in May or June and plug with putty to kill grubs. Infested areas may be covered with burlap to prevent adult emergence.
BOXELDER BUG	Manitoba maple, ash.	Black bugs, with red longitudinal stripes on wings and front part of body, injure the tree by sucking the sap from leaves and tender growth. Large numbers may enter houses in autumn.	Spray foliage thoroughly with malathion 50 E.C. at 2 tsp/gal water. Apply from mid-July to early August when nymphs and adults present on leaves.
BOXELDER TWIG BORER	Manitoba maple.	Dormant buds destroyed in late fall and early spring, new terminal growth burrowed in May and June, and some leaf stripping during mid-summer.	Spray foliage with malathion 50 E.C. (pending registration) at 2 tsp/per gal water. Apply from mid-July to mid-August to control larvae feeding on leaves.
BUDWORMS	Spruce, pine.	Needles eaten in June by coppery-brown caterpillars about 1 inch long. Silken feeding shelters constructed in foliage.	Spray foliage with one of the following: malathion 50 E.C. at 4 tsp/gal water; Cygon 4E at 5 tsp/gal water; or phosphamidon at 4 tsp/gal water. Apply when larvae are feeding openly on needles. (Pending registrations.)
CANKER-WORMS	Maple, elm, ash, etc.	Holes appear in the newly developed leaves in early spring; later foliage completely devoured by brownish-green caterpillars which spin silken threads.	Spray foliage with malathion 50 E.C. at 1 tsp/gal water; or methoxychlor at 3 tsp/gal water. Apply when "shothole" feeding on leaves evident.
CARAGANA PLANT BUG	Caragana.	Adults about ¼ in. long and mostly bright red on top. Insect overwinters as adult and causes damage by sucking the plant sap.	Spray foliage thoroughly with malathion 50 E.C. at 2 tsp/gal water. Apply when plant damage noted.
FOREST TENT CATERPILLAR	Poplar, willow.	Leaves eaten in May and June by dark, hairy caterpillars that cluster on stems and branches but do not make tents.	Spray foliage with malathion 50 E.C. at 1 tsp/gal water. Apply when feeding damage to the leaves first noticed.
GALL INSECTS	Elm, Manitoba maple, basswood	Various shaped galls formed in early season, usually on underside of leaves. Includes spiny oak gall, poplar petiole gall, poplar vagabond gall, and maple bladder gall.	Damage from gall insects usually not serious. Removing and burning galls a helpful control practice.
LEAF BEETLES	Poplar, willow.	Foliage skeletonized in June by black grubs causing scorched appearance, or devoured by small to medium vari-colored adult beetles.	Spray trees with malathion 50 E.C. at 2 tsp/gal water; or carbaryl (Sevin 85 S.P.) at 3 tsp/gal water. Apply when leaf feeding damage noted.
LEAF HOPPERS	Siberian elm, Manitoba maple.	Whitish spots on elm leaves. Maple leaves stunted and discolored. Caused by small, green active insects on leaves.	Spray leaves with one of the following: malathion 50 E.C. at 2 tsp/gal water; carbaryl (Sevin 85 S.P.) at 3 tsp/gal water; or methoxychlor at 4 tsp/gal water. Apply when insects seen or plant damage noted.
LILAC LEAF MINER	Lilac.	Larvae feed between the upper and lower surfaces of leaves in their early stages; later, leaves are skeletonized causing them to dry up.	Treat with Cygon 2E; or Cygon 4E diluted to half strength. Apply as stem treatment in a 3-in. band for each 1 in. diameter of stem. One application about mid-June and again at the end of July.
PINE NEEDLE SCALE	Spruce, pine.	Yellowish mottling of foliage; crawlers active early June. Small, waxy, white, elongated scales remain on needles all year.	Spray foliage thoroughly with malathion 50 E.C. at 4 tsp/gal water. Apply first application between June 5-20 when crawlers are active and second application about mid-August to kill females that survived first application.
SAWFLIES	Spruce, larch, fir.	Needles eaten in June and July by small "caterpillars;" brownish with red heads on spruce and fir; grayish with black heads on larch.	Spray foliage with malathion 50 E.C. at 3 tsp/gal water. Apply when first needle damage occurs.
SCURFY and OYSTER SHELL SCALES	Cotoneaster, dogwood plum, apple, Mountain ash.	Plants appear unhealthy with sparse foliage and dead branches; caused by grayish, pear-shaped scales clustered on the bark.	Spray trees thoroughly with one of the following: malathion 50 E.C. at 4 tsp/gal water; diazinon 50 E.C. at 3 tsp/gal water; or carbaryl (Sevin 85 S.P.) at 3 tsp/gal water. Four weekly applications commencing June 1. Dormant oil applications helpful.
SPINY ELM CATERPILLAR	Elm, willow, poplar.	Foliage devoured by purplish, spiny caterpillars which feed in clusters.	Spray leaves with malathion 50 E.C. at 1 tsp/gal water. Apply when larvae are seen on the leaves.
SPRUCE SPIDER MITE	Spruce, larch.	Brownish mottling of needles, with fine, silken webbing around twigs between needles. Mites pin-point in size.	Spray trees thoroughly with Kelthane E.C. (1.78 lb actual) at 3 tsp/gal water; or malathion 50 E.C. at 3 tsp/gal water. Apply when damage noted and repeat as necessary during the season.

Note: Before using any pesticide read the label on the container.

*Rates given are for small quantities of spray material using pesticide formulations readily available on the market and applied with a standard type high-pressure sprayer. Larger quantities of spray material may be prepared using the formula: 6 tsp = 1 fl oz and 8 tsp = 1 oz dry measure.

For further information on pests of trees and shrubs send your inquiry to one of the following government agencies: the local agricultural representative; the Pest Control Specialist, Department of Agriculture Regina; Department of the Environment, Canadian Forestry Service, 501 University Crescent, Winnipeg 19, Manitoba; Canada Department of Agriculture, Research Station, University Campus, Saskatoon; Canada Department of Regional Economic Expansion, Tree Nursery, P.F.R.A., Indian Head, Saskatchewan; Department of the Environment, Canadian Forestry Service, Immigration Building, Prince Albert, Saskatchewan.

*Abbreviations used in the tables are as follows: E.C. – Emulsifiable Concentrate; S.P. – Soluble Powder or Sprayable Powder; W.P. – Wettable Powder; tsp – teaspoon; tbsp – tablespoon; gal – gallon; oz – ounces; lb – pound.

TABLE VI*
CHEMICAL CONTROL OF INSECT PESTS OF LIVESTOCK AND POULTRY

Beef Cattle: Warbles and Lice

Chemical	Method and Time of Application	Frequency	Rate of Application	Dosage	Important Instructions and Comments
CO-RAL 25% W.P.	High-pressure spray to wet hide. 300-400 psi pressure Sept. 1 to Dec. 15. Early treatment recommended.	Once during season.	Suspension of 2 lb 25% W.P./10 gal water.	About 1 gal/animal. Depends on thickness of hair coat.	DO NOT USE: On dairy cows in milk at any time or dry dairy cows within 14 days of freshening; within 7 days of slaughter on calves under 3 months old; within 10 days of shipping, weaning, vaccinating; on sick, fatigued, or stressed livestock; follow label instructions carefully. Wear protective clothing including respirator. Avoid inhalation or contact with skin or eyes. DO NOT USE pyrethrins and related compounds after treatment with Co-Ral.
RUELENE 25E (Spray treatment)	High-pressure spray to wet hide. 300-400 psi pressure. Early fall treatment best.	Once during season for warbles. May be repeated in Dec., Jan., Feb., for lice if animals previously treated in fall.	Emulsion of 64 oz of 25% E.C./20 gal water.	About 1 gal/animal.	DO NOT USE: On dairy cows in milk at any time or dry dairy cows within 28 days of freshening; within 28 days of slaughter; on calves under 3 months old; within 10 days of shipping, weaning, vaccinating; on sick, fatigued, or stressed livestock.
RUELENE 25E (Pour-on treatment)	Pour on backline. Not during Dec., Jan., or Feb., except as indicated under instructions.	Once during season for warbles. See last column for instructions on repeat treatment for lice.	Emulsion of 1 gal of 25% E.C./3 gal water.	1 fluid ounce of mixture/100 lb body weight.	Same precautions as with spray. May cause temporary skin irritation. If re-infestation of lice occurs, re-treat but not within 28 days. Treatment during Dec., Jan., and Feb. should be limited to animals which have been fall treated with a systemic insecticide for warbles. Louse control with pour-on chemicals is mainly limited to sucking lice.
RUELENE 12R	Ready to use. Pour on.	Once during season for warbles. See last column for repeat treatment for lice.	Ready to use. No dilution necessary.	½ fl oz/100 lb body weight.	Same precautions as with spray. May cause temporary skin irritation. If re-infestation of lice occurs, re-treat but not within 28 days. Treatment during Dec., Jan., and Feb., should be limited to animals fall treated with systemic for warbles.
NEGUVON (Pour-on treatment)	Pour on. Not during Dec., Jan., or Feb, except as indicated under instructions.	Once during season.	Ready to use. No further dilution.	½ fl oz per 100 lb body weight.	DO NOT USE: On dairy cattle in milk —on animals less than 300 lb, sick, convalescent, or in stressed condition. —10 days before or after shipping, weaning, or dehorning; or after exposure to infectious or contagious disease. —in conjunction with oral drenches, other internal medications, or with other organic phosphates. —within 21 days of slaughter or 7 days of freshening. —or during Dec., Jan., Feb, unless animals have been fall treated with systemic insecticides.
ROTENONE (Derris) (spray treatment)	High-pressure spray before warbles drop. Chemicals must penetrate warble openings.	Three or four times at 2 or 4 weeks' interval.	Suspension of 1 lb 5% W.P./10 gal water.	1 gal/animal.	Marketed under various brand names. Loses insecticidal properties in presence of alkali or sunlight. Highly toxic to hogs.
ROTENONE (Derris) (Direct application)	Direct application with stiff brush.	Three or four at monthly intervals.	5 lb 5% W.P./10 gal water.	2 qt/animal.	Apply before warbles drop. Chemical must penetrate opening. Rubber clothing (including gloves) MUST be worn in wash treatments.

Beef Cattle: Lice

MALATHION	Spray in Oct. or Nov.	Once.	1 gal 50% E.C./100 gal water.	1 gal/animal.	Not on young calves or sick animals. Fall treatment most effective.
MALATHION 4% dust	Dust.	Repeat in 10 days and thereafter as required.	Apply thoroughly.		
MALATHION 2%	Back rubber.	Continuous.	Ready to use solution.		Use one back rubber for every 35 to 45 animals and recharge it every 2 or 3 weeks
MALATHION 50% E.C.	Back rubber.	Continuous.	1 part to 24 parts mineral oil.		Use one back rubber for every 35 to 45 animals and recharge it every 2 or 3 weeks.
RONNEL (Korlan)	Back rubber.	Continuous.	Korlan—24E 1 gal/24 gal mineral oil.		Do not mix with used motor oil.
ROTENONE	Spray or wash. Dust.	Twice—12-16 day interval. Three times—3-week intervals.	1 lb of 5% W.P./10 gal water OR 1% dust.	1 gal/animal. Visible cover.	See comments on Rotenone under warbles. Dust is useful in winter when sprays and systemic insecticides are contra indicated.
CARBARYL (Sevin)	Spray.	Once.	Mix 10 oz of 80% W.P. in 10 gal water.	½ to 1 gal per animal.	Do not apply within 1 week of slaughter. Do not exceed stated dosage.
CIODRIN 20 E.C.	Spray.	Repeat if necessary but not more than once every 7 days.	Mix 1 pint in 10 gal water.	½ to 1 gal per animal.	Repeat if necessary, but not more than once every 7 days. Do not treat calves under 6 months of age.

Beef Cattle: Horn Flies, Mosquitoes, Stable Flies, and Face Flies

CIODRIN 20 E.C.	Spray.	Repeat if necessary but not more than once every 7 days.	1 pint/10 gal water.	½-1 gal/head for large animals. Proportionately smaller dose for smaller animals.	Repeat if necessary but not more than once every 7 days. Do not treat calves under 6 months of age.
CIODRIN 20 E.C.	Back rubber. Keep back rubbers moist with insecticide mixture.		1 pint to 3 gal diesel fuel or mineral oil.		As above. Do not use crankcase oil or used lubricating oil. No wait period before slaughter.
MALATHION 4% dust	Sprinkle on back and sides.	Repeat as required not more than once a week.	Actual concentrate.	2 oz/animal.	
METHOXYCHLOR 50% W.P. or 25% E.C.	High-pressure spray.	Intervals of 2 to 3 weeks.	1 lb W.P./10 gal water. 4 qt 25% E.C./5 gal water.	2 qt/animal.	Do not use within 7 days of slaughter. Do not use on sick animals. Repeat in 3 weeks.

*Abbreviations used in the tables are as follows: E.C. – Emulsifiable Concentrate; S.P. – Soluble Powder or Sprayable Powder; W.P. – Wettable Powder; tsp – teaspoon; tbsp – tablespoon; gal – gallon; oz – ounces; lb – pound.

Chemical	Method and Time of Application	Frequency	Rate of Application	Dosage	Important Instructions and Comments
RONNEL (Korlan) **24E**	Back rubber.		Korlan 24E 1 gal to 2 gal mineral oil or diesel No. 2 fuel.		Do not use crankcase oil or used lubricating oil. No wait period before slaughter.
RONNEL (Korlan) **24E**	High-pressure spray.	Every 3 weeks or as needed.	Korlan 24E 2 gal/100 gal water.	1-2 qt/animal.	Do not use within 7 days of slaughter or on sick animals or young calves.
VAPONA 20% E.C.	Brush on face for control of face flies.	Daily.	1 tsp in 3 oz water and 3 oz corn syrup.	1 tsp/head.	Prepare fresh daily out of doors or in properly ventilated room. Keep away from children, fire, and heat. Do not contaminate feeds. Store in original container. Wash outside of can before storage.
CARBARYL	Use as per instructions under lice.				
LINDANE	High-pressure spray.	As required to give control.	2 lb 25% W.P./100 gal water or 32 fl oz 25% E.C./100 gal water.	2 qt/animal.	Do not use on sick animals or within 30 days of slaughter.

Dairy Cattle: Warbles

ROTENONE (Derris) 1.5% dust	Dust back—use stiff brush.	3 or 4 times at intervals of 2-4 weeks.	Actual concentrate.	4-5 oz/animal.	Apply when warble openings are present in hide.
ROTENONE 5% W.P.	High power spray.	3 or 4 times at intervals of 2-4 weeks.	1 lb/10 gal water.	2-4 qt/animal.	Apply as above.
ROTENONE 5% W.P.	Brush.	3 or 4 times at monthly intervals.	5 lb/10 gal water.	2 qt/animal.	Apply as above.

Dairy Cattle: Lice

ROTENONE 1% dust OR 5% W.P.	Dust. Visible cover. High power spray.	3 times at intervals of 3 weeks. Twice—12-16 days.	Actual concentrate. 1 lb/10 gal water.	2-3 oz/animal. 1 gal/animal.	Work dust well into hair and down to skin. Spray mix at 400 psi to wet skin.
CARBARYL (Sevin)	Spray after milking.	Once only.	10 oz of 80% W.P. to 10 gal water.	1 gal/animal.	Do not apply on the underline and udder. Use immediately after milking and wash udder thoroughly before next milking. Do not contaminate milking utensils.
CIODRIN 20 E.C.	Spray.	Repeat as necessary but not more than once every 7 days.	1 pt/10 gal water.	½-1 gal/animal.	Repeat if necessary but not more than once every 7 days. Do not treat calves under 6 months of age.

Dairy Cattle: Horn Flies, Stable Flies, Face Flies, Mosquitoes

CARBARYL (Sevin)	Spray.	Not more than twice weekly.	Use as described above for lice.	1 gal/animal.	Precautions as above for carbaryl under lice.
CIODRIN 20 E.C.			Use as described above for lice.		
RONNEL (Korlan Dairy Cattle Spray)	Apply as mist to dampen hair.	Not more than once a day.	Available as ready to use solution specially for dairy cattle.	2-3 fl oz/animal.	Do not wet hide or spray udder. Apply 15-20 minutes before milking.
DICHLORVOS (Vapona)	Apply as mist to dampen hair.	Not more than once a day.	Available as ready to use solution specially for dairy cattle.	1-2 fl oz/animal.	Apply AFTER milking.
PYRETHRINS and PIPERONYL BUTOXIDE	Mist.	Daily.	Ready to use sprays or aerosol bombs.	1-2 fl oz/animal see label.	Follow label instructions for application rates. Formulations of these materials are marketed under various brand names. Some contain chemicals not suitable for dairy cows.
CIODRIN **MALATHION** **RONNEL**	These three chemicals are the only ones recommended for use in back rubbers for dairy cattle. These materials are available in ready-to-use and concentrated forms. Concentrates should be diluted as label directs, using No. 2 diesel oil or mineral oil. DO NOT USE used crankcase oil.				
VAPONA 20% E.C.	Follow instructions as for beef cattle.				
CARBARYL	Use as per instructions under lice.				

Sheep: Keds and Lice

ROTENONE 1% dust	Dust.	Twice for lice. Interval 2 weeks; repeat as required for keds.	Actual concentrate.	Dust—visible cover.	
ROTENONE 5% W.P.	Spray or dip.	Twice—interval 2 weeks.	1 lb/10 gal water.	1 qt/animal.	
MALATHION 50% E.C.	Spray—after shearing.	Once.	2 qt/50 gal water.	1 qt/animal.	DO NOT USE on milking goats.
TOXAPHENE 40% W.P.	Spray—after shearing.	Once.	6¼ lb/50 gal water.	1 qt/animal.	DO NOT USE WITHIN 28 days of slaughter. Not on milking goats.
TOXAPHENE 40% W.P.	Dip—after shearing.	Once.	6¼ lb/100 gal water.		DO NOT USE within 28 days of slaughter. Not on milking goats.
TOXAPHENE 60% E.C.	Spray—after shearing.	Once.	3½ qt/100 gal water.	1 qt/animal.	DO NOT USE within 28 days of slaughter. Not on milking goats.
LINDANE 25% E.C.	Spray—after shearing.	Once.	16 fl oz/50 gal water.	1 qt/animal.	DO NOT USE within 30 days of slaughter. Not on milking goats or sick animals.
METHOXYCHLOR 50% W.P.	Spray—after shearing.	Once.	1 lb/10 gal water.		DO NOT USE within 30 days of slaughter. Not on milking goats.
RONNEL (Korlan 24E)	High-pressure spray.	As required.	1 pt 24E/12 gal water.	1 qt/animal.	DO NOT USE on sick animals or within 28 days of slaughter.

Sheep: Blow Flies

LINDANE 25% W.P.	Spray or dip.		4 lb/25 gal water.		Use spray pressure of 100 psi to treat infested but not sick animals. Not within 30 days of slaughter.

Chemical	Method and Time of Application	Frequency	Rate of Application	Dosage	Important Instructions and Comments
Horses: Lice and Winter Ticks					
CARBARYL (Sevin) 5% Dust OR 80% W.P.	Dust entire animal. Spray.	As necessary. Not more than twice weekly. Once or twice as necessary.	Ready to use. 3 ½ lb in 50 gal water or equivalent amount.	1 lb/head. 1 gal/animal.	
BENZENE HEXACHLORIDE (BHC)	Spray.	Once. Repeat if necessary.	1 lb BHC 12 W.P. in 12 gal water.	1 gal/animal.	
CO-RAL 25% W.P.	Spray.	Once.	1 lb/10 gal water.	1 gal/animal.	
Swine: Lice					
MALATHION 50% E.C.	Spray.	Once—if necessary repeat in 14-18 days.	1 gal/100 gal water.	2 qt/animal.	Not on sows with suckling pigs. Do not expose suckling pigs to the insecticide. Avoid contaminating feed and feeding and watering equipment. Remove manure before spraying and spray pen. No wait period before slaughter.
MALATHION 4% Dust		Twice—if further treatment necessary repeat at 14- to 18-day intervals.	Actual concentrate.	Dust thoroughly.	See above.
RONNEL (Korlan)	High-pressure spray.	As required to give control.	Korlan 24E 1 pt to 12 gal water.	1-2 qt/animal.	Do not use on: sick animals or on sows with suckling pigs.
Swine: Mange and Lice					
MALATHION 50% E.C.	Spray.	Once—if necessary repeat in 12 days.	1 gal/50 gal water.	2 qt/animal.	See instruction above for Malathion—Lice.
CO-RAL	Spray.	Once—if necessary repeat in 10 days.	1 lb/10 gal water.	Spray to runoff.	DO NOT USE within 7 days of slaughter or within 10 days of shipping, weaning, vaccinating, or on sick or distressed animals.
Poultry: Lice					
MALATHION 4% Dust	Dust.	Once, repeat if reinfestation occurs.	Actual concentrate.	1 lb/100-150 birds.	Also apply to floor, litter roosts, and nests.
Poultry: Chicken Mite					
MALATHION 4% Dust OR					Apply to floor litter 1 lb to 40 sq ft and spray roosts, nests, and walls 1% suspension—see below.
MALATHION 50% E.C.	Spray to dampen birds.		16 fl oz/5 gal water.		Apply to floor litter, roosts, nests, and walls.
Poultry: Northern Fowl Mite					
MALATHION 4% Dust	Dust.	Once, repeat if reinfestation occurs.	Actual concentrate.	1 lb/100 birds.	Also apply to floor litter, roosts, nests, and walls, 1 lb to 40 sq ft.
Poultry: Lice, Chicken Mite: Northern Fowl Mite					
CO-RAL 25% W.P.	Low-pressure spray.	Repeat if necessary but not more often than weekly.	5 oz (1 2/3 cups) to 7 gal water.	1 gal to 120-150 birds or ½ oz/bird.	Also apply to floor, litter, roosts, nests, and walls.

TABLE VII*
FLY CONTROL IN FARM BUILDINGS

Chemical	Rate of Application	Method	Important Instructions and Comments
DIAZINON 50% E.C.	16 fl oz/10 gal water.	Treat walls, windows, and resting places with coarse (wet) spray.	Do not apply to animals and remove from barn before spraying. Do not contaminate animals' feed or water. Hazardous to operators without protective clothing. Quite toxic to birds, especially ducks. Do not use in poultry houses or in milk processing rooms. Repeat every 3-4 weeks.
DIMETHOATE (Cygon or Rogor)	16 fl oz/4 gal water.	See above.	Do not apply to animals. Remove all livestock from building before spraying. Do not contaminate animals' feed or water. Do not use in milk processing rooms. Repeat every 6-8 weeks.
MALATHION 50% E.C.	1-2 gal/50 gal water.	See above.	Do not contaminate animals' feed or water. Do not use in milk processing rooms. Not for direct application to animals in this concentration.
RONNEL (Korlan 24E)	1-2 gal/50 gal water.	See above.	Not for direct application to animals. Remove lactating dairy animals from building before spraying. Do not contaminate feed or water. Do not use in milk processing rooms. Repeat in 4-6 weeks.
BAYTEX 50% E.C.	3 fl oz/1 gal water.	For outside use only. Spray.	Repeat every 8 weeks. Do not use inside buildings.
RABON and DICHLORVOS MIXTURE (Ravap)	1 qt/5 gal water. (1% solution)	Treat walls, windows, and resting place with coarse spray.	Not necessary to remove animals before treatment. Do not contaminate feed and water. Do not use in milk rooms or in poultry houses.

Cords or bands impregnated with insecticides and other fly baits are available commercially. These give good control when used in connection with label recommendations. Protective gloves should be worn when handling these materials.

In Milk Processing or Storage Rooms

PYRETHRINS—PIPERONYL BUTOXIDE		Use as space spray applied with an atomizer or aerosol bomb.	Do not direct spray to utensils or apply when storage tanks are open. Follow label instructions carefully.
DICHLORVOS (Vapona)		Use only impregnated plastic strips sold commercially. Use as directed.	Do not use Dichlorvos sprays inside milk rooms.

*Abbreviations used in the tables are as follows: E.C. – Emulsifiable Concentrate; S.P. – Soluble Powder or Sprayable Powder; W.P. – Wettable Powder; tsp – teaspoon; tbsp – tablespoon; gal – gallon; oz – ounces; lb – pound.

PLANT DISEASES (For figures, see color section, pages 78-82.)

Plant diseases have plagued crops ever since agriculture began; more than once they have caused famine and massive economic loss. Even today in the western world with advanced farming practices, we cannot be complacent about diseases. In Saskatchewan common root rot reduces wheat and barley yields by an estimated 5 to 15 percent annually. While rusts and smuts of cereals in recent years have been fairly well controlled, they still remain a threat to production and could quickly become serious. Various diseases on the stems and leaves of rapeseed can cause significant losses and may become more prevalent in future. While there is no single simple solution to the plant disease problem, the use of good farming practices and control methods described in this section will do much to reduce losses in yield and grade caused by diseases.

CAUSES OF PLANT DISEASES

Like human diseases, those on plants can be grouped into two major categories, infectious and non-infectious.

Infectious Diseases

Most plant diseases are in this category. They are caused when plants are infected by microscopic parasites (fungi, bacteria, and viruses) that feed on the plants they infect. The disease symptoms result mainly from the effect the feeding has on the plant host. Generally the parasites multiply in the plants. For example, a single rust spore infects a plant and produces a rust pustule, containing thousands of spores. All these spores may be spread to other plants and start new infections. Some of the parasites, for example, the agent causing aster yellows, can attack a wide range of host plants; others, for example, the fungus causing net blotch of barley, are restricted to one host.

Non-Infectious Diseases

These are not caused by parasites but by a variety of environmental factors, such as adverse weather, poor soil conditions, and injury from improperly used chemicals. For example, low temperatures cause winter injury to forage crops; both high and low temperatures may result in yellow leaf banding on cereal seedlings; iron deficiency causes chlorosis (yellowing) between the leaf veins of crabapples and many ornamentals, while low soil nitrogen causes general yellowing of many plants; carelessly used 2,4-D may drift onto broad-leaved plants like sunflower and cause various malformations.

It is very important to determine the cause of a disease because control measures usually are aimed at suppressing the cause rather than curing established disease in annual crops. Frequently the symptoms of a disease are quite characteristic and can be used for its identification. Sometimes similar symptoms can result from different causes and the assistance of a specialist may be required to diagnose the disease.

TRANSMISSION OF PLANT DISEASES

Transmission implies both carry-over of the disease parasites from one season to another and their spread during the growing season. In Saskatchewan, carry-over usually involves a dormant stage. While carry-over and spread are often closely related processes, they may sometimes be brought about by quite different agencies. For example, the fungus causing ergot of cereals usually overwinters with the seed or in the soil, but summer spread takes place through the air and depends on insects and rain splash. In any case, recognizing means of transmission is extremely important in devising means of disease control.

There are three main ways in which parasites overwinter: a. In the soil; b. on stubble and plant trash at the soil surface; and c. with the seed. Those that overwinter in the soil are generally hardest to control and crop rotation may be the primary means of effecting this. Some of those that overwinter on plant trash may also be partly controlled by crop rotation, and through sanitation methods such as burning. A number of the seed-borne diseases can be controlled by chemical seed treatments. Often, however, an organism that causes a disease may overwinter in more than one of these ways and consequently several methods of control may be necessary.

Summer spread of the parasites that cause diseases can take place in a number of ways. For example, a few can grow short distances in the soil. Many root parasites can be spread through the soil by the use of cultivating machinery. Parasites that cause disease of leaves and stems usually are spread through the air. Wind, rain splash, insects, and actual contact between adjacent plants are important in different diseases as means by which the parasites are carried from one plant to another.

INFLUENCE OF ENVIRONMENT ON PLANT DISEASES

Soil Fertility

While maintenance of good soil fertility is obviously important to avoid non-infectious deficiency diseases, soil nutrient levels can also be very important factors affecting the severity of infectious diseases. Browning root rot of wheat, a fungus disease, is especially severe in summerfallow soils that are low in phosphate and can be controlled by fertilizer application. On the other hand, overfertilizing of lawns in late summer can lead to more severe snow mould the following spring.

Weather

This has a major influence on almost all plant diseases and usually the relationship is quite complex. Moisture, temperature, wind, and light are recognized as the most important factors. Most fungus spores require water to germinate and penetrate plant tissues; this water may come from rain, fog, or dew. Wind and rain move spores about and thus help to spread disease. Strong winds and high air temperatures tend to reduce infections because of their drying effect on plant surfaces. Thus, the fungi causing rusts, leaf spots, and mildews infect plants most readily when rainfall and dew are frequent and temperatures are moderate. Common root rot infections on wheat occur most readily when dry periods alternate with occasional rain, and the disease is more severe in warm than in cool soil.

Man and Monoculture

Man increases plant disease damage to his crops through his widespread practice of monoculture, or the growing of extensive acreages of single crops and single varieties. These favor epidemics of infectious disease for a number of

reasons. First, disease can spread more rapidly in populations where the plants are all close to each other. Second, in order to increase yields, most crop plants have been bred to be very uniform in character. Thus, if one plant is susceptible to a disease, all the plants of the variety are. In resistant varieties, if the resistance breaks down due to a change in the parasite population, then the breakdown applies to the entire variety and not just a few plants. This is what happened with Thatcher wheat and stem rust in the early 1950s in Saskatchewan, and with southern corn leaf blight in the U.S. corn belt in 1970. Another problem of monoculture is that plant breeding and abundant fertilizer use have frequently resulted in rank stands of plants. These may create an environment within the crop that is ideal for the development and spread of disease. A final harmful aspect of monoculture is that growing the same crop year after year in the same place can result in progressive buildup of disease organisms in the soil.

There is no simple solution to the monoculture problem because our agriculture is highly specialized and intensive in order to achieve efficiency. Crop diversification, where possible, may tend to ease the burden on farmers in years of major disease outbreaks. Crop rotations should, of course, be practised and, whenever possible, resistant varieties should be used. Efforts are being made to develop varieties with broader disease resistance to better withstand changes in the parasites.

EIGHT POINTS FOR CONTROL OF PLANT DISEASES

1. Use Resistant Varieties

The simplest and surest method of disease control is to use resistant plant varieties. Cereals resistant to rusts and smuts are outstanding examples. Flax wilt has been almost eliminated, and flax rust controlled for many years by this means. Resistance of a variety is unlikely to be permanent because the parasites have the ability to change; and so, for the control of a disease such as stem rust of wheat, new resistant varieties are continually being produced. Resistant varieties should be grown wherever practical. (See reference 3, Grain Crops section, page 63, and Forage Crops section, page 55.)

2. Practise Crop Rotation

Crop rotation can allow time for infective residues from diseased crops to decompose, and for the parasitic fungi or bacteria to die. Rotation may consist of summerfallowing, which also aids weed control and moisture conservation, or the land may be seeded to a crop not susceptible to the particular disease. Many diseases, especially leaf diseases like net blotch of barley are specific on individual crops, and fairly good control can be achieved by crop rotation.

3. Practise Sanitation

Sanitation consists of the removal of infected plant debris by mechanical means or by burning. Since many parasites overwinter on straw, stubble, and other plant debris on the soil surface where they are in a favorable position to infect subsequent crops, sanitation may be a very effective control measure. Generally, direct removal of plant debris is feasible only in small gardens, where it can be very useful in controlling root rot of peas and bacterial blight of beans. In the field it is important to retain a trash cover to protect the soil from erosion. (See Soils and Fertilizers section, page 87.) Hence, burning stubble, which favors erosion, and causes loss of soil nutrients, is not recommended for cereals, despite its beneficial effect with plant diseases. However, with certain perennial forages, burning crop residues can be safely used to control diseases.

4. Maintain Good Soil Fertility

Some non-infectious diseases are caused by, and some infectious diseases are more serious with, low soil nutrient levels. Thus maintaining good soil fertility is vital to disease control. It is worthwhile to have soil tests done to determine appropriate fertilizer applications. (See Soils and Fertilizers section, page 93.)

5. Sprays and Dusts

Sprays and dusts are effective in the control of some leaf and stem diseases. Costs in relation to potential savings are important in deciding whether they are worthwhile. In this connection, although presently they are rarely applied to most Saskatchewan field crops, they may be useful in home gardens. For example, micro-fine sulfur may be applied as a dust, or wettable sulfur as a spray to control powdery mildews of lawns and many other plants. In using fungicides and insecticides, extreme care should always be taken to follow carefully the instructions on the label.

6. Avoid Chemical Injuries to Plants

Overapplication or misapplication of various chemicals can damage the crops they are supposed to protect. Likewise, chemical spray drift can be extremely harmful to non-target crops and other plants. For example, excessive or untimely 2,4-D on cereals causes swelling of the crown and lower nodes, reduced crown root development, distorted heads, sometimes an onion leaf effect, and finally reduced grain yield. The drift of 2,4-D may extensively damage nearby susceptible crops, garden plants, and trees. (See Weed Control section, page 70.) Sunflower and rapeseed are especially sensitive, and show various malformations and flower sterility. Leaves of trees (such as Manitoba maple) and garden plants may become thickened, brittle, cupped, and stringy-looking, with prominent veins and brown margins. Some fungicides may cause lawns to be "burnt" if applied on a hot day. The key to avoiding chemical injuries is to follow carefully the instructions on the label concerning timing and dosage. Herbicides should never be used on windy days, and where there is a risk of drift damage the less volatile forms, such as 2,4-D amine, should be used. (See Weed Control section, page 70.)

7. Sow Sound, Clean Seed

Many disease parasites can be carried on or in seed, and as contaminants or in the debris with seed. Shrivelled, broken and cracked, or discolored seed may be quite susceptible to attack during germination by seed- and soil-borne parasites. It is a recommended practice to sow sound, clean, high-quality seed. Certified seed best meets these standards and in addition its use assures genetic purity.

8. Seed Treatment

Seed dressings are available that contain fungicide for disease control, or insecticide for insect control (see Insect Pests of Plants and Livestock, page 100) or fungicide and insecticide (dual purpose) for both disease and insect control. Seed dressings come as dusts, wettable powders, or liquids; these may be applied by seed-treating machines or applicators, by hand mixing, or in the case of special powders, in the drill box with the seed at the time of seeding. Thorough mixing and uniform application are essential for the best results.

Seed treatment with fungicide effectively controls some of the seed-borne diseases and also may give some protection against seed rot and seedling blight. Because different treatments may be needed for different diseases it is important to select the right one. Choice of product thus will depend upon kind of seed to be treated, disease to be controlled, and your preference for type of formulation. Product labels show the purposes for which they are sold, directions for use, and handling precautions.

Most seed-treatment chemicals are poisonous. The chemicals should be used only for the purposes stated on the label; the directions given there should be followed and the precautions given should be heeded exactly. It is unlawful to sell treated grain to commercial elevator companies. Treated grain should never be used for feed or be allowed to become mixed with grain used for food or livestock feed. Care should be taken to prevent exposure of treated grain to wildlife. Chemicals should be stored in the original containers, and empty containers should be disposed of safely. The Canada Seeds Act requires that any grain seed treated with a poisonous substance and offered for sale shall be stained a conspicuous color and labelled "Poisonous; do not use as a feed. This seed has been treated with (name of poisonous substance)."

New seed dressings are constantly being developed. Consequently, for information on seed treatments consult extension specialists such as your agricultural representative.

Cereals—Various disease-causing parasites of cereals are seed-borne. Most of those that cause smut or seedling blight can be controlled by seed treatment fungicides. Even the loose smuts of wheat and barley which are transmitted within the seed can be controlled by systemic fungicides. (Systemic fungicides are taken up by plants and work from within.)

Examination of cereal seed may indicate the need for treatment. Tests for smut spores carried on the surface of seed are available upon request from some grain companies. Pedigreed seed such as "Certified" seed of barley is tested for smut content by the Plant Products Division (see Services section, page 165), and it must meet specified tolerances. For any of these tests it is important that the sample is representative of the seed lot and that it is taken after the seed is cleaned. Varieties that are resistant to smuts should require no treatment for these diseases. For information on varieties refer to the annual publication **Varieties of Grain Crops for Saskatchewan.**

Oilseeds—Practically all flax diseases except viruses are seed-borne. To prevent seed decay and damping-off or seedling blight it is advisable to treat all flaxseed with a fungicide.

Rapeseed and mustard seed of high germination benefit little or not at all from treatment; however, seed of 80 percent germination or lower may improve somewhat.

Forage Legumes and Grasses—Seed treatment with some fungicides may improve stands by reducing seedling blight. The fungicides also control head smut of grasses. Legume seed should be treated well in advance of being inoculated with a bacterial culture.

Vegetables—Seed treatments are recommended for the control of seed rot, damping-off, and root rot of peas, corn, beets, and cabbage. Dust seed dressings are in common use. They may be applied by shaking seeds and dust together in a bottle, then screening off the excess dust.

DISEASES OF CEREALS AND GRASSES

(See References 1 and 2)

Rust (See Table I and Figs. 1, 2, and 3)

Cereal rusts found in Saskatchewan are the stem and leaf rusts of wheat, oats, barley, rye, and grasses. The best control is to grow resistant varieties (see Grain Crops section, page 63, and **Varieties of Grain Crops in Saskatchewan)** but those resistant to one race of rust may be susceptible to another. The appearance of new races of the rust fungi on previously resistant varieties may be expected from time to time.

The rust fungi have complex life cycles, including several spore stages. Only the summer spores, however, are a factor in the spread of stem rust in Saskatchewan. Successive generations of the red summer spores are produced every 10 to 14 days and cause new infections if the weather is suitable. With favorable weather the rust soon increases to epidemic proportions on susceptible varieties.

Source of Rust Epidemics—The cereal rusts do not overwinter in Saskatchewan, but rather in the winter cereal areas of Southern Texas and in Mexico. There rust survives in the red (summer) spore stage. In early spring, rust spores are blown northwards by prevailing winds and pass through the winter wheat areas of the Great Plains and finally reach the spring wheat regions of the Prairie provinces. The first appearance of stem and leaf rust, generally in early summer, occurs in Southern Manitoba and Southeastern Saskatchewan. The severity of wheat rust in Saskatchewan thus depends largely on the intensity of rust development in the winter wheat areas of the United States, and consequently the number of rust spores blown northward into Canada.

Other Rusts—Flax and sunflower rusts differ from the cereal rusts in that all the different spore stages occur on the one host plant. The black spores overwinter in the field and may give rise to new infections in the spring. Crop rotation is therefore necessary when a crop has been rusted, unless resistant varieties are available.

"Green Rust" (Black Mould)—When cereals have ripened prematurely due to severe heat, drought, or frost, stems and heads may show a green or black discoloration due to mould growth. The moulds flourish in wet periods during the harvest season and give the plants a rusted appearance. They are not, however, true rusts, although they are often called "green rust;" they do not directly reduce yields, although they contribute to weathering of the grain.

Root Rots (See Table II and Figs. 11 and 12)

Common Root Rot—This is the most prevalent root disease of cereals and grasses in Saskatchewan. It is frequently overlooked by farmers. In general, common root rot tends to weaken the plants, causing a decline in the crop, which is most noticeable towards maturity. Occasionally, common root rot appears as a seedling blight. Stands of plants may be seriously reduced, particularly in grasses. A prematurity blight phase of the disease sometimes occurs. It is characterized by bleached dead plants with rotted bases that are conspicuous in the green crop.

The infection may arise in the spring from contaminated seed, but much more frequently it comes from spores in crop residues on the surface of the soil. The fungi causing it live on and in the surface soil over winter. In late May or early June the first points of infection appear on parts of the seedlings near the soil surface. Infections in the crown zone continue through the growing season, and severe lesions may develop in the crowns, crown roots, tiller buds, and subcrown internodes.

In warm weather, with limited soil moisture, the disease advances in the underground parts of plants, causing a decline in vigor and a sharp reduction in yield. Under good growing conditions, however, plants may tolerate a fair amount of root rot without conspicuous yield reductions. As a result, crop losses are difficult to measure.

Studies have shown that most grain fields contain many spores of common root rot fungi in and on the surface soil and trash. Disease usually is as high in fallow as in stubble fields because the spores can survive for more than a year in soil. A highly resistant or an immune crop such as flax or rapeseed in the rotation and then a year of fallow provide some control. The more resistant wheat varieties should be sown (see **Varieties of Grain Crops for Saskatchewan**). Shallow seeding helps by reducing the likelihood of infection. Plowing trash down has some value also, but may favor wind erosion of the soil.

Browning and Take-All Root Rots—Browning root rot occurs most commonly in wheat on summerfallow. The use of phosphatic fertilizers has greatly reduced losses from browning, which has now become a minor disease. The disease can reappear promptly, however, when good levels of phosphate are not maintained in the soil.

Take-all is a disease of wheat and barley, though rye and some grasses may also be attacked. It occurs most commonly in the Gray and Black soil Parkland areas when wheat follows wheat, or wheat is grown after breaking grassland. Crop rotation is an effective control measure.

Injuries Confused with Root Rot Damage—Injuries to crops caused by alkali, drought, soil drifting, 2,4-D, wireworms, or wheat stem maggots are frequently mistaken for root rot damage, and conversely, root rots may be mistaken for other troubles.

Low Temperature Diseases

Snow-Mould—This is a soil-borne fungus disease of grasses and winter cereals, which appears in the early spring when the snow is melting. The fungus attacks the crown tissues and the plants may be killed outright or they may produce weak, spindly shoots when growth begins. The disease may occur in small or large patches. All common grasses are susceptible except bromegrass and crested wheatgrass. (See Table III.)

Winter Injury—Excessive cold, desiccation, and abnormal conditions such as icing or alternate freezing and thawing may kill or weaken grasses and winter cereals. Some species of grasses are hardier than others. Winter injury may also contribute to snow-mould infection. (See Table III.)

Smuts (See Table I and Figs. 4 to 9)

Most of the smuts that occur on cereals and grasses in Saskatchewan destroy the grain of the plants that they attack. Black spore masses develop in the place of kernels or spikelets and are characteristic of these diseases. The symptoms usually are conspicuous. Losses are roughly proportional to the percentage of smutted heads in the crop. A few smuts of grasses form their spores on the stems and leaves of the plants. The grasses, because they are perennials, become infected permanently.

Almost all the smuts are seed-borne. Some, such as bunt of wheat, the covered and false loose smuts of barley, and covered and loose smuts of oats, are carried on the seed; others, namely loose smut of wheat and loose smut of barley, are carried in the seed.

Formerly, these last two diseases could not be controlled by chemical seed dressings. The development of systemic fungicides which penetrate the seed, however, has changed this picture. The smuts can be readily controlled by fungicides, and the use of resistant varieties. (See **Varieties of Grain Crops for Saskatchewan.)**

Leaf Diseases (See Table III and Figs. 19 to 26)

Fungi, bacteria, viruses, and nutrient deficiencies may cause blotches, spots, chlorosis, and stripes on leaves of cereals and grasses. If enough leaf area is killed, the vigor of growth is lessened and seed set may be reduced or prevented, or the grain may become shrivelled. The most common leaf diseases are net blotch of barley, scald of barley and grasses, halo blight of oats, leaf and stem spots of brome grass, and speckled leaf blotch of all cereals.

Ergot (See References 4 and 5, Table II, and Figs. 13 to 18)

Ergot is a disease of cereals and grasses. Black or purplish sclerotia (fungal bodies) appear in the heads instead of normal seeds. Ergot is very common in rye and occurs in wheat, barley, and many grasses. It rarely affects oats. Ergot does not attack rapeseed, flax, sunflower, or legumes, although other sclerotia found in seeds of these crops are sometimes mistaken for ergot. Losses from ergot result more from a reduced market value of an affected crop than from a reduced yield. There are specified tolerances for ergot in seed, commercial grain, and feed. Ergot sclerotia contain poisons. Any grain with an ergot content of 0.1 percent or more should be considered dangerous. (For effects of ergot on livestock see Livestock section, page 149.)

DISEASES OF LEGUMES (See Reference 2 and Table IV)

Winter Crown Rot

This disease and snow mould of grasses are caused by the same fungus. Alfalfa and all of the clovers are susceptible. Plants are damaged late in the fall and in early spring. Scattered infected plants may be found while more severe outbreaks of the disease are characterized by irregular patches of dead plants. A dark brown rotting of the crown occurs while the root remains firm and apparently healthy until natural decay sets in. Only a portion of the crown may be affected and diseased plants may recover partially. This disease may be confused with winter injury. However, in true winter injury the plants do not start to grow and the roots are shredded and rotten.

Bacterial Wilt

The bacteria which cause this disease enter alfalfa plants in the spring through wounds produced by winter injury, insects, or mechanical damage. The disease occurs in the second or third year of growth and the first sign is usually a gradual stunting and yellowing followed by abnormal growth and wilting. A yellow-brown discoloration of the woody tissue beneath the bark of the main taproot confirms the presence of this disease. Severe damage is generally confined to irrigated areas. The varieties Beaver and Roamer are highly resistant and Rambler is slightly resistant.

Seedling Blight

All species of legumes are susceptible. Rotting of seed and death of young seedlings are caused by soil fungi which do most damage in wet, cold soils.

Crown Bud Rot

This disease is caused by a combination of several soil fungi. It develops most rapidly in early spring. Brown spots occur on the young buds and shoots near the soil surface and rotting may spread later into underlying crown tissue. This disease occurs commonly in irrigated fields after the first season.

Black Stem (See Fig. 39)

This is a leaf and stem disease of alfalfa and sweet clover. The fungus which causes the disease overwinters in the field on crop debris and is carried over on seed. The disease appears in early summer as small, irregular, dark-brown or black spots on the lower leaves and at the bottom of young stems. Spots may run together to form large black areas which often girdle and kill older stems. Severe leaf spotting causes defoliation and hence serious losses of forage. There are presently no blackstem-resistant varieties of alfalfa. Hay crops should be cut early, while spring burning of crop debris may afford some control.

Common Leaf Spot

This fungal disease is recognized by small, dark-brown, circular spots that develop on leaves of alfalfa plants. As the spots mature a small raised, lighter colored disc appears in the centre of each spot. Alfalfa plants are not killed by this disease, but when severely infected most of the lower leaves drop off. Resistant alfalfa varieties have been produced, but they are not adapted to conditions in Western Canada. Control measures are the same as recommended for black stem.

Yellow Leaf Blotch (See Fig. 37)

This is a fungal disease which attacks the leaves of alfalfa only. It appears first as elongated orange-yellow

streaks on the leaves and later in the year numerous small black spots appear in the yellow area. Substantial defoliation may occur, particularly in dry weather. The severity of the disease increases with the age of the stand. There are no resistant varieties. Good crop sanitation is the best means of control.

Sclerotinia Stem Rot

This is similar to sclerotinia stem rot of rapeseed.

Deficiency Diseases and Viruses

These cause stunting, discoloration, and general unthriftiness. The application of recommended fertilizers will correct most deficiencies. Some legume viruses have native plants of the pea family as hosts; destruction of these will assist in control.

DISEASES OF RAPESEED, TURNIP RAPE, AND MUSTARDS

(See References 2 and 6, and Table V)

Staghead or White Rust

The first symptom to appear in the spring or early summer consists of creamy-white pustules on the undersides of the leaves (see Fig. 29). These produce the summer-spore stage of the fungus. As the plants become more mature, the disease causes individual flowers or entire flower stalks to develop into swollen, brown, spiny structures. (See Figs. 31 and 33.) These do not produce seed but contain overwintering spores which are released during harvesting operations. Spores or fragments of the stagheads fall to the ground or become mixed with the seed. Blisters containing spores of this type are also produced on stems (see Fig. 32) and pods. They split open in the fall, exposing brown spore masses. All turnip rapeseed (Polish) varieties are susceptible to this disease but **varieties of the Argentine type are completely resistant.** (See Table V for control measures.)

Sclerotinia Stem Rot (See Fig. 30)

Alfalfa, clovers, sunflowers, and several weeds are affected, as well as rapeseed and mustard. Bleaching of parts of stems or of entire plants may occur. In the latter case, the prematurely ripened plants may be seen scattered throughout the green crop. Such plants pull easily, and their stems tend to shred. When they are slit open, black, hard, oval fungus bodies (sclerotia) are often found inside. These fall to the ground or mix with the seed during threshing and carry the disease over winter. Rotation with cereal crops, including a fallow year, thorough cleaning of seed to remove sclerotia, and control of weeds reduce infection.

Alternaria Black Spot (See Fig. 36)

Spots of various sizes occur on stems, pods, and leaves. Those on leaves are brown or gray, while those on pods and stems are generally black. The disease is commonly seed-borne, with most of the infection occurring on the seed surface. Several weeds of the mustard family often are infected. Crop rotation, control of weeds, and the use of well-cleaned seed will help reduce infection. Seed produced in drier areas generally is free of the disease or carries only low levels of infection. Seed treatment may be beneficial under certain conditions. (See Table V.)

Ring Spot (See Fig. 35)

The fungus responsible produces elongated, purple to gray, speckled areas on stems and pods of rapeseed and mustard. By late summer, entire plants may be discolored. Crop rotation reduces infection.

Blackleg

Whitish spots are produced on leaves, stems, and pods. These spots are speckled with small, black bodies from which ooze pink to purple spore masses in moist weather. Stems may be weakened, resulting in lodging. Basal parts of old stems and overwintered stubble may become conspicuously blackened. Several weeds of the mustard family also carry the disease.

Aster Yellows (See Fig. 28)

This disease occurs on many plants including rapeseed. Round seedless bladders develop on rapeseed instead of the normal pods. (See Aster Yellows under Flax Diseases.)

Basal Stem Rot or Late Root Rot (See Fig. 34)

Several fungi are involved in this disease. A clearly defined, oval, brown lesion commonly less than 1 inch long is produced at the base of the stem. The diseased area may have a black border. One member of the disease complex is seed-borne. The cultivated mustards are readily attacked. Several weeds, as well as flax, safflower, and sunflower are also susceptible.

FLAX DISEASES (See Reference 2 and Table V)

Most flax diseases are seed-borne and also overwinter on flax straw and stubble. All flaxseed should be treated with a fungicide. Flax should always be planted on fallow land or on the stubble of any crop except flax. When flax is sown beside an old flax-stubble field, the diseased straw should be buried, if possible, before the new crop emerges.

Several of the flax diseases usually develop late on the maturing crop. Early seeding helps crops to escape disease and reduces the danger of fall frost damage. (See Livestock section, page 149, and **Problem Feeds for Livestock and Poultry** for the dangers of frosted flax to livestock.)

Rust and Wilt

The growing of recommended varieties has adequately controlled these diseases.

Aster Yellows

This disease may damage flax in years when the gray leafhopper is plentiful. This insect transmits the disease from infected weeds and crop and garden plants. Helpful measures are early seeding, the adequate control of weeds in and around flax fields to remove local sources of infection, and the location of flax fields as far away as possible from waste land.

DISEASES OF SPECIALTY CROPS

Small acreages of the mustards, sunflower, safflower, buckwheat, field peas, lentils, and potatoes are grown in different areas of Saskatchewan. Some of these have become more important in recent years with the move to crop diversification. The plants have a variety of different diseases, some of which attack other plants too. It is therefore important to practise careful rotation with non-susceptible crops to control such diseases. For example, as well as affecting sunflower and field peas, sclerotinia stem rot also affects rapeseed, mustard, and alfalfa, so that none of these crops should follow each other in a field. Specific diseases of these specialty crops are mentioned in other parts of this section, in particular in Tables V and VII.

VEGETABLE AND FRUIT DISEASES

(See Tables VI and VII)

Diseases of fruit and vegetables may be carried in the soil, in or on the seed, or in plant refuse. Weeds sometimes

harbor diseases. Crop sanitation by plowing under or, in some cases, by burning crop refuse is helpful. Good tilth and soil fertility should be maintained with manures and other fertilizers.

Spraying and Dusting

Peas, tuberous-rooted begonias, strawberries, and several of the perennial flowers, including delphiniums and chrysanthemums, are commonly affected with powdery mildew. Early and repeated application of micro-fine sulfur dust, wettable sulfur spray, or other commercial preparations for mildew control is effective.

Potatoes in Saskatchewan rarely require spraying or dusting for disease control, although they may need application of insecticides.

Storage

Success in the storage of fruits and vegetables depends largely on a sound product stored under suitable conditions. (See Horticulture section, page 135.)

DISEASES OF LAWNS (See References 7 and 8)

Snow Mould

Several low-temperature fungi cause snow mould, and their prevalence is related to factors such as the depth of snow cover, whether snow fell on frozen or unfrozen ground, the species and variety of turf grass, the age of the lawn, and the fertility and length of the turf, especially in late fall. Most of the damage from snow mould takes place under the snow cover, so applications of fungicide must be applied in advance of snowfall. Symptoms are seen at or just after snow melt. The commonest types on domestic lawns are Fusarium snow mould and LTB snow mould, the latter caused by an unnamed low-temperature basidiomycete. In Fusarium snow mould the webs of fungal threads are pinkish and dense, and in LTB snow mould they are fluffy and white. (See Figs. 40 and 41.) In another kind, sclerotinia snow mould, small, dark, round resting bodies (sclerotia) of a fungus may be found in plant debris on the killed and weakened patches of grass. (See Fig. 42.) On areas of turf receiving some warmth from basements or underground pipes the "pink" snow mould may develop. Affected patches bleach and may remain conspicuous until summer. Although with care grass in the patches may recover, successive attacks of snow mould allow the invasion of weeds, including weed grasses. All common lawn grasses appear susceptible. Avoid overfertilizing in late summer and mow the grass to a height of 2½ to 3 inches until winter. Use snow fences to maintain an even snow cover. Control may be assisted by applying fungicides before snowfall, during winter melts (if any), and at spring thaw. The manufacturer's label on a fungicide container shows the uses of the product and provides directions for its application and precautions to be observed.

"Melting-Out"

This is caused by complexes of fungi which may destroy leaves, crown, and roots of bluegrasses and fescues, or produce general unthriftiness. Melting-out may be controlled by lifting the mowing height to 2½ inches and making applications of a fungicide, the container label of which recommends its usefulness for this turf disease.

Powdery Mildew

This occurs in most years and is particularly severe in the shade or in locations with poor "air drainage." Leaves are coated with gray or white powder and may yellow as far as the crown. Most bluegrasses and fescues are susceptible. Use micro-fine sulfur or a turf fungicide recommended for mildew control as a spray at 10-day intervals to kill the fungus. Improve "air drainage" from the site.

Fairy Rings

These result from the activities of soil fungi. They may show as circles or ribbons of rank grass in summer and fall, and then as bare or poor areas of growth the following spring. Fungal threads in the soil below the rings may be so dense that the grass roots cannot obtain sufficient moisture. Some of the fungi produce materials toxic to the grass roots. In mild cases, the effects of the rings may be masked during the growing season by normal applications of nitrogenous fertilizer and by liberal watering. To eradicate: a. Spike the ring and apply water daily until the soil is very soft (at least for 1 month); or b. strip the turf and completely excavate the infected soil; or c. break up the ring soil and fumigate it with a suitable volatile fungicide (e.g., formaldehyde): level with fresh soil, turf or sow the area. Partial excavation or poor fumigation may eliminate only some of the fungus; the remaining pieces may then start new rings. Applications of fungicides to undisturbed turf seldom provide ample control of fairy rings; even the most effective turf fungicides rarely give more than partial kill of the deep-seated fungal threads.

Many turf fungicides are very poisonous. Great care should be taken in handling and storing them. Lock them away when not in use. Wear rubber gloves when handling. After use, wash the hands, gloves, utensils, and appliances. Keep off treated lawns until after the next watering.

TREE DISEASES

Trees in prairie regions often are near the limit of their ability to survive because of extreme cold and low moisture. Any slight, further hardship may cause unhealthy symptoms. Windbreak trees may be expected to show signs of decline at a fairly early age. At this stage, broadleaved trees (but not conifers) should be heavily cut back to stimulate new growth. The most certain protection against disease is to give the best possible care. Vigorous trees generally recover from most diseases. Pay close attention to recommendations on tree planting and care. (See Horticulture section, Preparation and Planting of Shelterbelts, page 134.)

Drought Injury

Fine root tips die in extremely dry soil, and the trees are therefore unable to take up enough moisture the following spring to permit normal leaf development. Symptoms of drought injury may range from sparse, late development of leaves to die-back of crowns or death of the tree. Heavy "distress" crops of blossoms and seeds may develop. The conservation of soil moisture by all available means, including cultivation and mulching, is the best defence against drought injury. Irrigation should be applied when practicable.

Trees on lawns can suffer from drought even when the grass receives enough water. A shallow grass sod can intercept all the water applied in light springlings and leave none to penetrate to the deeper tree roots. A few thorough soakings are better for both grass and trees than frequent light sprinklings.

Girdling Diseases

Stems or branches are said to be girdled when the bark is severely diseased, injured, or broken all the way around. Girdling prevents food in solution from passing downward through the inner bark, and thus causes starvation below the girdled point. It also permits the exposed sapwood to dry out, preventing the sap from rising above this point and causing die-back in the crown. Some common causes of girdling are cankers, wounds, and bark-boring insects.

Cankers—Cankers are usually caused by fungi that attack and kill the bark locally. Infection commonly occurs through wounds, frequently those caused by the feeding and egg laying of insects. Cankers begin as small areas of diseased bark, which may enlarge year after year until the tree or branch is completely girdled and die-back results. Cankers are particularly common in poplars; they also often develop on the shaded moist base of dense shrubs like elderberry or Chinese elm in hedges. On spruce, pine, and other coniferous trees, cankers cause conspicuous discharge of resin from the diseased bark.

Cankered branches should be pruned off close to their base before the disease spreads to the main stem of the tree. If already on the main stem, the stem should be cut back with a clean, slanting cut, well below the diseased part, and close above a large, healthy branch. Large cut surfaces should be treated with wound dressing. (See Wounds.) All diseased and dead parts should be removed and burned immediately. When shrubs are heavily cankered at ground level it may be best to grub them out entirely and replace them. For treatment of fire blight cankers on mountain ash (rowan), apple, crabs, etc., see Table VII.

Wounds—Unbroken, living bark provides natural protection against diseases that commonly attack through wounds.

The following causes of wounds in bark are avoidable: Trees struck by passing farm implements and vehicles; rabbits and mice, which feed on the bark; livestock (see below); axes carelessly used; fence wires fastened to trees. Roots may be wounded or completely torn apart by too deep cultivation. FIRE causes serious wounds; bark and foliage may be killed if heated only slightly above natural temperatures.

The healthy healing of wounds may be aided by prompt treatment. Cut away ragged edges and slivers with a sharp knife or chisel, and shape the wound to a point at top and bottom. Paint at once with shellac, and/or follow with a dressing of bordeaux paint or other reliable wound dressing obtainable from seed and garden supply dealers; **do not** use house paint, roofing cement, etc. Bordeaux paint is made by stirring bordeaux powder and raw linseed oil into a paste; let it stand for an hour or so, and stir it again. When open checks appear in the exposed wood of old wounds, or when the paint weathers away, apply additional dressings. This protects the wood from drying and also from becoming infected by fungi.

Sapsuckers: A Species of Woodpecker—These birds cut rows of squarish holes in the bark of various trees, and return repeatedly. Dead areas of bark or complete girdling of branches or main stem may result. Other kinds of woodpeckers are not injurious.

Control is difficult because sapsuckers are protected by law. Their return visits can be discouraged by applying wound dressing to the attacked areas. (See Wounds.) This also aids healing. Scaring devices are helpful.

Injury by Wire Fences—Fence wires, bracing wires, clotheslines, etc., should never be fastened directly to valuable trees. Tree growth forces the bark more and more tightly against the wire, eventually causing a serious wound. A tree around which wire has been wrapped will eventually girdle itself. Place a guard of wood, old tire, or hose under the wires.

Foliage Diseases

Leaves often become discolored or dry in circular spots or large irregular areas. These conditions may be caused by fungi, frost, dry soil, etc. Leaf diseases usually are not sufficiently harmful to justify the cost and trouble of spraying for control (except for certain diseases of fruit trees and shrubs—see Table VII). (See also Insect Pests section, page 111, for mites, scale, etc., which attack spruce, pine, and other leaves.)

Winter Browning of Conifers

Browning of the foliage of spruce and other conifers occurs commonly in late winter or early spring, when warm sunshine and drying winds cause evaporation of moisture from the leaves while the wood and soil are still frozen. Affected trees usually recover if other conditions are favorable. Ensure that conifers go into the winter with adequate moisture by watering in late fall. If browning has occurred, water as soon as possible in the spring.

Injury by Chemical Weed Killers

Trees may be seriously injured when weed-killer spray or its volatile component is carried to them by wind. (See Weed Control section, page 70.)

Injury by Livestock

Livestock should be fenced out of plantations and woodlots. Serious injury results when livestock trample the roots, compact the soil, browse and break seedling twigs and branches, rub the bark away, etc.

Woodlots

In farm woodlots, disease-control measures should be applied to entire stands rather than to individual trees. Keep fire and livestock out of the woodlot. Avoid wounding trees. Remove diseased and dead trees in cutting operations. Fungal growth (conks, punks, mushrooms) on trees are sure signs of advanced heart rot. Heart rot may be suspected in trees with large, old wounds, or where excessive resin escapes through the bark.

INQUIRIES

Inquiries about diseases of field and garden crops and lawns may be sent to the Department of Biology, University of Saskatchewan, Saskatoon; the Canada Agriculture Research Station, Saskatoon; or your agricultural representative. Inquiries about tree diseases should go to the Canadian Forestry Service, Department of the Environment, Immigration Building, Prince Albert, Saskatchewan. Specimens of diseased plants, whole ones whenever feasible, should be included.

For information on woodlots, write to the Director of Forests, Department of Natural Resources, Prince Albert, Saskatchewan.

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TABLE I

Rusts and Smuts of Cereals and Grasses

Crop	Disease	Symptoms	Control
Wheat, Oats, Barley, Rye, Grasses	Stem rust (See Fig. 1.)	Dusty, raised, reddish brown oblong spots on leaves, stems, and heads, becoming black as the plant matures. The red spore dust may adhere to hands, clothing, or machinery.	Use resistant varieties as recommended (see Grain Crops section, page 63, also *Varieties of Grain Crops for Saskatchewan*). Early-seeded crops and early-maturing varieties tend to escape rust damage. Chemical control methods are known, but not used.
Wheat, Oats, Barley, Rye	Leaf rust, Crown rust (oats) (See Figs. 2 and 3.)	Dusty yellow to light orange, small round to oval spots on leaves and sheaths, becoming black as the plant matures.	
Wheat	Bunt (Covered or stinking smut) (See Fig. 4.)	Bluish green heads of smutted plants often are slow to mature. Affected kernels (bunt balls) are gray-green then brown, usually larger than normal kernels but resembling them in general appearance. Bunt balls are easily broken as during threshing to release a powdery black mass of fungus spores. The spores may lodge on and darken the brush ends of healthy seed. Bunt usually has a strong unpleasant odor like putrid fish.	Use resistant varieties. (See Grain Crops section, page 63, and *Varieties of Grain Crops for Saskatchewan*), or use smut-free seed if available. Certified seed of barley must meet tolerance levels for loose smut. If cereal seed carries smut or is from a diseased crop, it is advisable to treat it with a fungicide, the container label of which shows it is suitable for the smut. Only a systemic fungicide effectively controls loose smut of wheat and barley.
Barley	Covered smut (See Fig. 5.)	Heads are dull gray color. Spikelets become masses of purple-black spores covered, rather permanently, by a thin membrane. Clumps of smut are conspicuous in threshed grain.	
Barley	False loose smut	Chaff and seeds are replaced by loose powdery smut masses that break up and blow away at flowering time. The heads are like those in loose smut but are darker in color.	
Oats	Covered and loose smut (See Fig. 9.)	Dark brown spore masses replace spikelets. They may be of covered or loose type or intermediate.	
Wheat, Barley	Loose smut (See Figs. 6 and 8.)	The heads become dusty masses of black spores soon blown away by winds, leaving the bare rachis. Not evident in threshed grain, lives over in healthy appearing kernels.	
Grasses	Head smut (See Fig. 7.)	Loose type of head smut. Powdery black masses of spores replace the spikelets. Plants once infected will produce smutted heads every year.	Treat seed with a recommended fungicide.
Corn	Smut	Galls or tumors, at first covered by a gray membrane occur on any aerial parts, especially ears and tassels, later releasing black, powdery mass of spores.	Rotate crops. When practicable pick and burn smut galls as soon as they appear. This will reduce soil infestation.

TABLE II

Root Rots, Ergot, and Seed Diseases of Cereals and Grasses

Crop	Disease	Symptoms	Control
Wheat, Oats, Barley, Rye, Grasses	Common root rot (See Figs. 11 and 12.)	Brown discoloration of stem bases, roots, crown, and lower leaf sheaths, somewhat more distinct on barley. Plants generally shorter and produce fewer stems and grains per head. Sometimes plants bleach and die, prematurely producing shrivelled grain.	The more resistant varieties of wheat should be grown whenever possible (see *Varieties of Grain Crops for Saskatchewan*). Growing nonsusceptible crop in the rotation is recommended, e.g., flax, rapeseed, or legumes. A 2-year period of freedom from susceptible crops will eliminate much of the infection sources. Avoid deep seeding. (See Kernel smudge.)
Cereals, Grasses	Seeding blight	Seed rotting and death of seedlings before or shortly after they emerge, causing thin stands.	Treat cereal and grass seed with an appropriate fungicide. Avoid deep seeding.
Wheat, Barley, Grasses	Browning root rot	Large, brown areas in crops mainly on summerfallowed land in June, caused by extensive browning and dying of the lower leaves. The tips of the crown roots are rotted. Stooling is reduced, seedlings stunted, maturity delayed, and yields lowered.	Use phosphatic fertilizers and maintain soil fertility (see Soils and Fertilizers section, page 90). Sow seed in a firm seed-bed. The working in of combine stubble reduces the disease. Avoid burning stubble. In some districts, partial summerfallow has been beneficial. Thatcher wheat shows some resistance.
Wheat, Barley, Grasses	Take-all root rot	Frequently occurs in scattered plants or in patches, particularly in Gray and Black soil Parkland areas. Plants are stunted and bleached. The roots are blackened and brittle. Plants often die prematurely and produce shrivelled grain.	After breaking native or cultivated sod use a rotation such as wheat, oats, wheat, fallow, followed by any good rotation. Maintain soil fertility. Take-all may become troublesome if wheat follows wheat.
Grasses, Rye, Barley, Wheat	Ergot (See Figs. 13 to 18.)	Conspicuous hornlike purple to black fungus bodies produced in place of seeds; present in threshed grain. Poisonous to man and animals.	Cut all nearby grasses before they come into head. Clean seed to remove ergot bodies. If a few ergot bodies remain in the cereal seed, plant at least 2 inches deep. Cultivate deeply after an ergoty crop to bury the sclerotia.
Wheat, Barley	Kernel smudge (black-point) (See Fig. 10.)	Light- to dark-brown discolorations usually at the end but may spread somewhat over the kernel. Occasionally caused by a common root rot fungus.	Clean the seed thoroughly to get rid of light kernels. Treat seed with a fungicide for seedling blight control.
Wheat	Bacterial black-point (Basal glume rot)	Light-brown rot at the base of the spikelet, when severe extending into the rachis and into the base of the kernels causing an inky-black point at the embryo tip. Kernels are sometimes shrunken.	
Wheat seed	Piebald or yellow-berry	A starchy condition of the endosperm giving the kernels a yellow appearance wholly or in part. Embryo unaffected. Frequently found in Black and Gray soil areas.	Use nitrogen-phosphorus fertilizers on fallow and stubble crops (see Soils and Fertilizers section, page 91). Increase soil nitrogen by growing legumes. Thatcher is resistant.
Oats	Blast (non-parasitic)	Conspicuous, white, sterile spikelets, usually the lower ones.	No specific control is known. Avoid herbicide injury. Maintain soil fertility.
Wheat, Rye, Barley, Oats	Frost injury in cereal seed	Immature, greenish kernels and distinct transverse wrinkling of the seed coats of the larger kernels in wheat and rye. Frequently indicated by a whitening and looseness of the hulls of oats. Severely frozen barley kernels are light in weight and shrunken.	Avoid use of frosted seed; otherwise clean seed to remove shrivelled kernels. Have the seed tested for germination.

TABLE III

Leaf Diseases of Cereals and Grasses

Crop	Disease	Symptoms	Control
Wheat	Yellow leaf blotch	Yellowish-brown spots on leaves in June and early July causing lower leaves to die.	Crop rotation.
Wheat	Splotch	White and yellow spots and blotches, progressively more numerous or bigger on the sixth to the top leaf.	Nitrogen fertilizers reduce the disease. Durum wheats, especially Ramsey, are susceptible. Bread wheats are highly resistant.
Wheat, Barley, Oats, Grasses	Septoria leaf and glume blotch (See Figs. 20, 22, and 27.)	Light brown spots or blotches on the leaves and glumes, later gray and speckled as the black, tiny fruit bodies develop.	Rotate with nonsusceptible crops. Oats may be rotated with wheat and barley.
Barley	Net blotch (See Fig. 23.)	Brown blotches containing a network of darker lines, on leaves at any stage of plant growth. Blotches may fuse to form linear streaks.	Rotate with nonsusceptible crops. Seed treatment with fungicide for seedling blight control may reduce disease.
Barley, Wheat	Bacterial leaf blight (See Fig. 24.)	Spots usually near leaf tips, at first pale green and water soaked. Often long streaks develop which turn golden, then pale brown. Droplets or whitish scales may appear in the streaks.	
Wheat, Barley, Rye	Spot blotch (See Fig. 19.)	Dark-brown round to oblong spots that if numerous may fuse to form blotches.	
Barley, Rye, Some Grasses	Scald (See Fig. 21.)	Oval spots on leaves at first gray-green, later drying out rapidly with centres becoming light gray and margin a dark-brown ring.	Rotate with nonhost crops such as wheat, oats, oilseeds.
Oats, Barley, Wheat	Gray speck	Areas in affected fields appear patchy and brown beginning at about the fifth leaf stage. Spots on leaves are gray, white to brown. Leaves often break over in the basal half. Severe damage may result in failure to head or in death.	Drill in feed-grade manganese sulphate at the rate of 100 lb per acre at seeding time.
Oats	Halo blight	Spots or blotches on leaves and sheaths, with dead central portions surrounded by pale yellowish-green margins, giving a halo effect.	Use resistant varieties. Rotate crops. A 10-minute steep in water held at 135°F is satisfactory for infected seed.
Cereal seedlings	Leaf banding	Extreme temperatures (high or low) on consecutive days may cause narrow, white bands on young leaves and sheaths about ½ in. to 1 in. apart. The top portions of seedlings frequently break over.	Slightly heavier seeding may be used as a precautionary measure. Trash cover in stubble fields gives some protection by providing shade. Soil packing is helpful.
Grasses, winter cereals	Snow mould (See Figs. 40, 41, and 42.)	Conspicuous fungus growth overrunning leaves and crown tissues, causing dead patches in crop or turf. Occurs in spring frequently under or near melting snow. See page 117.	Crop rotation and sanitation. For lawns (see Lawn Diseases, page 120).
Grasses	Cold and winter injury	Plants dead in spring, usually in patches. Crown and roots decayed.	Use hardy varieties. Avoid late fall cutting, pasturing, and burning.
Barley, Oats, Wheat, Rye, Grasses	Yellow dwarf (virus)	Upper leaves of oats yellow or red, of other plants golden yellow. Infected plants may be stunted and scattered among healthy plants.	Early varieties planted early tend to escape infection.
Wheat, Oats, Barley, Bromegrass	Striate mosaic (virus)	Fine, parallel, yellow or white streaks on young leaves, chlorosis and necrosis of older leaves. Plants are stunted.	Thatcher and Chinook wheat are resistant. Durum wheats are susceptible.
Bromegrass	*Selenophoma* leaf and stem spot (See Fig. 26.)	Oblong or linear spots with brown borders and speckled centres on lower leaves. Later, spots may affect upper leaves, stems, and heads of hay and seed crops.	Graze pastures clean, cut stubble short and pick up all hay from hay and seed crops to reduce carry-over of infection in crop debris. Stubble burning will reduce incidence but occasionally lowers seed yield. Magna less susceptible than Carlton or common.
Bromegrass	*Pyrenophora* leaf spot (See Fig. 25.)	Oblong or elliptical leaf spots with yellow halos. Withered leaf blades when severe.	As for *Selenophoma* leaf spot. Most severe when fertility is low. For fertilization, see Soils and Fertilizers section, page 92.
Timothy	Leaf spot	Small circular or oval spots with purple borders which may be closely clustered together on leaves and stems.	Maintain soil fertility in seed crops. Pick up hay. Burning of stubble and crop debris not recommended.
Lawngrass	Various diseases, including Fairy Ring and Snow Mould	See Diseases of Lawns, page 120.	

TABLE IV

Diseases of Alfalfa, Clover, and Lentils

Crop	Disease	Symptoms	Control
Alfalfa	Crown bud rot	Rotting of crown buds in early spring.	Avoid late cutting and excessive grazing. Crop rotation.
Alfalfa	Bacterial wilt	Plants weak with numerous fine stems and small, yellow leaves. Woody tissue of root may show a brown ring.	Crop rotation. (See recommended resistant varieties, Forage Crops section, page 54.)
Alfalfa, Clover	Winter crown rot	Single plants or patches dead in early spring. Crown and upper root decayed, lower root sound. Fungus sometimes seen covering the dead plants.	Avoid late cutting and grazing.
Alfalfa, Clover	Root rot	Crowns and roots decay during growing season. Plants wilt, turn yellow, and may die.	Crop rotation, including fallow and cereals.
Alfalfa, Clover, Lentil	Sclerotinia wilt basal rot	Wilting of leaves, decay of roots. Cankers may form at base of stem and hard, black bodies on or within the stem.	Rotate with cereal and grass crops; avoid rapeseed and sun flower land. Use clean seed.
Alfalfa, Clover	Seedling blight	Seed rotting and death of seedlings before or after they emerge; thin stands.	Treatment of seed with a fungicide may improve stand. If seed is to be inoculated, treat first, and inoculate just before seeding.
Alfalfa, Clover	Winter injury (See Fig. 38.)	Single plants or patches dead in early spring. Crowns and roots shredded.	Use recommended varieties. Avoid late grazing.
Alfalfa, Clover	Black stem (See Fig. 39.)	Black or dark-brown spots on stems, leaves, and pods. Defoliation.	Spring burning of stubble and trash. Cut hay crops early.
Alfalfa, Clover	Common leaf spot	Round, brown spots on leaves, often with raised centres. Defoliation.	Spring burning of stubble and trash. Cut hay crops early.

Crop	Disease	Symptoms	Control
Alfalfa	Yellow leaf blotch (See Fig. 37.)	Orange-yellow streaks on leaves. Defoliation.	
Lentil	Stem rot and gray mould	Wilting: Bleached areas on stems covered with gray, mouldy growth.	Crop rotation. Use clean seed.
Alfalfa	Downy mildew	Light-green top leaves, short internodes, small stems, leaves twisted and rolled, and covered with grayish, cottony growth.	No control.
Alfalfa, Clover	Viruses	Mottling or wrinkling of leaves. Alfalfa plants may appear broom-like.	Destroy leguminous weeds; maintain thick, healthy stands.
Red clover	Powdery mildew	Gray, powdery growth on upper surface of leaves. Leaves turn yellow.	No control.
Red clover	Northern anthracnose	Brown, sunken areas on stems, cracking of stems, girdling of petioles, and death of flowers.	Crop rotation.

TABLE V

Diseases of Oilseed Crops and Buckwheat

Crop	Disease	Symptoms	Control
Flax	Rust	Light-yellow spots followed successively by reddish-yellow and reddish-brown to black spots on leaves, stems, and flower parts.	Use resistant varieties. The seed must be clean and free of tiny bits of rusted straw. Treat seed with suitable fungicide. Do not plant flax near land where a rusted crop was grown the previous year. Plow down rusted flax refuse by early June.
Flax	Seed decay and seedling blight	Flaxseed may rot or seedlings fail to emerge. Seedlings 1 to 4 inches high wilt, fall over, and die. Thin stands frequently result. Note: This trouble should not be confused with damage from frost and early heat canker.	Sow only sound, clean seed. All flaxseed should be treated with a fungicide at the rate recommended on the label. Flax should not follow flax.
Flax, Rapeseed, Mustard	Frost injury of seed	Immature, shrivelled, white seed; maroon and dark-green seed commonly appear in frosted flax.	
Flax	Die-back and scorch	The top third or, less commonly the whole plant, turns brown following hot, dry weather during ripening, and the grain usually lacks plumpness.	Early seeding may be beneficial. Early maturing crops may escape the heat damage of late summer.
Flax	Heat canker	Seedlings are girdled at ground level, collapse, and die. Partially affected plants often continue to grow and may eventually break over at ground level.	Early and thicker seeding. Sow in a north and south direction. Packing the soil at seeding time is beneficial.
Flax, Rapeseed, Mustard	Aster yellows (See Fig. 28.)	On flax: Yellowish leaves and fine branches bunched at top of plant; flower parts yellow-green to purple and bolls fail to form. On rapeseed: Round seedless bladders formed instead of normal pods.	Early control of weeds in the crop and on nearby roadsides and waste land. Early seeding may be beneficial.
Rapeseed, Mustard	White rust (See Figs. 29, 31, 32, and 33.)	Swollen, distorted, and spiny structures at stem tips. Green when young, sometimes covered with white spore masses; later becoming hard and brown.	Varieties of the Argentine type are completely resistant. Use these where feasible. Rotate crops. Control weeds of mustard family. Use well-cleaned seed.
Rapeseed, Mustard	Black spot (See Fig. 36.)	Round to oval black or lighter colored spots on stems, pods, and leaves.	Rotate crops. Use well-cleaned seed. Seed of 80% germination or lower may be treated with a fungicide at the rate recommended on the label.
Rapeseed, Mustard	Ring spot (See Fig. 35.)	Purple to gray, speckled, elongate spots on stems and pods.	Crop rotation. Control weeds.
Rapeseed, Mustard, Sunflower	Sclerotinia stem rot (See Fig. 30.)	Plants become bleached, pull easily. Stems shred easily, contain hard, black bodies about ¼-inch long near base.	Rotate with cereal and grass crops. Use clean seed.
Rapeseed, Mustard	Blackleg	Whitish spots on stems, leaves, and pods. Black bodies on these spots produce pink to purple spore masses.	Crop rotation and control of weeds of mustard family.
Rapeseed, Mustard, Flax, Safflower, Sunflower	Basal stem rot or Late root rot (See Fig. 34.)	Oval brown lesions at base of stem. Blackening of root. Fluffy white fungal growth on root.	Crop rotation. Control weeds, many are reservoirs for the disease causing parasites.
Rapeseed, Mustard, Sunflower	Herbicide drift injury	Distortion of leaves. Failure to set proper flowers. Prominent leaf veins. Swelling of stem bases in rapeseed and mustard. Note: In sunflower, individual plants vary in their symptoms, even when adjacent.	Take extreme care when spraying cereals near sensitive crops. Never spray during windy weather.
Sunflower	Rust	Dark-brown rust spots on leaves, especially the lower ones. Leaves fall in severe cases.	Rotate crops and plow down or burn litter from rusted crop. Keep down volunteer seedlings.
Sunflower	Head rot	Mature heads turn brown and rot before seed is set. A problem in wet weather.	No control known.
Safflower	Leaf spot (See Fig. 45.)	Light-brown spreading spots which may coalesce and blight entire leaf.	Crop rotation, use clean seed.
Safflower	Rust	Dark-brown to black rust spots on leaves.	Crop rotation, use resistant cultivars. Treat seed, if necessary.
Buckwheat	Stem rot	Wilting, rotted areas on stems covered with gray mouldy growth.	Crop rotation, use clean seed.
Buckwheat	Aster yellows	Slight yellowing of stems and leaves, failure to produce normal flowers.	Weed control in the crop and on nearby roadsides.
Buckwheat	Root rot	Wilting, darkening of stem base, stunting.	Crop rotation.

TABLE VI

Diseases of Potato and Tomato

Crop	Disease	Symptoms	Control
Potato	Bacterial ring rot (See Fig. 44.)	Rolling, wilting, and yellowing of leaflets, usually on a single stem. Tubers with a ring or partial ring of yellow-brown rotted tissue advancing from the stem end. In advanced stages the interior of the tuber may be rotted away leaving an empty shell.	Disinfect tools, bags, machinery, and storage houses with a quaternary ammonium compound, or with 5% Lysol, (1 pint in 4 gallons of water). Bags should be soaked in the solution for 2 hours; storage bins and machinery may be sprayed or washed. Use Certified seed.
Potato	Blackleg	Bright yellow foliage. Stunting, yellowing, reduced and erect branching, rotting and blackening of base of stem, easily pulled, soft rot at the stem end in the tubers.	Use disease-free or Certified seed. Do not plant in cold, wet soil. Seed pieces should be planted soon after they are cut. If necessary to hold them over, spread them out in a cool place, at temperature of 50-60°F. Small tubers planted whole may be of value. Rotate crops.
Potato	Leak	Affected tubers are rubbery to the touch, internal tissues are watery and cream colored, exuding a yellowish liquid when subjected to pressure. Infection takes place through skin breaks at harvest time. A problem in transit and early storage.	High temperatures coincident with early harvest favor the disease. Avoid leaving the tubers lying in the sun after digging. Provide adequate ventilation in the storage to lower humidity and cool the tubers. Handle potatoes carefully to avoid injuries.
Potato	Wilts	Severe wilting, stunting, and premature ripening of the plant. Brown ring frequently seen when the tubers are cut.	Do not plant potatoes on the same soil oftener than once in 4 years. Discard tubers for seed purposes if they have internal discolorations. Use Certified seed.
Potato	Rhizoctonia (Black Scurf)	Small, black fungus bodies adhere to the tubers. Sprouts may be killed. Base of stem may be girdled, causing formation of aerial tubers.	Select seed free from black scurf and delay planting if soil is cold and wet. Use a long rotation of crops and avoid old garden soils. Dig potatoes intended for seed before the tops have completely ripened.
Potato	Scab (See Fig. 43.)	Distinct, irregular, rough, corky spots on tubers.	Select disease-free seed. Use a long rotation and avoid freshly manured land. Scab is generally less where potatoes follow sweetclover. Netted Gem is resistant but is not suited to dry prairie conditions.
Potato	Viruses	Leaf and stem abnormalities such as mottling, crinkling, necrosis purple coloration, and leaf rolling, also spindle shaped tubers and stunting of the plants.	Use Certified seed. Remove diseased plants, including the tubers, from crop intended for seed. (These tubers may be used for food.) Control aphids.
Potato	Dry rots	Affected tubers shrink and often develop hollow pockets internally, filled with a powdery mass of fungus growth. The fungi causing dry rot usually enter the tubers through wounds at digging time or later.	Use care in digging and handling to avoid bruises. Allow the potatoes to dry off before they are placed in storage. Maintain good ventilation in the storage place and gradually lower the temperature in storage to 35-40°F.
Potato, Tomato	Early blight	Mostly on the leaves, but may invade tomato fruits and potato tubers. Leaf spots are circular, brownish black with concentric rings. Leaves may fall.	Timely and thorough spraying with a suitable fungicide will control early blight.
Potato, Tomato	Late blight	Purplish or brownish areas on leaves and stems with a water-soaked zone around each spot. Killing of the foliage may be very rapid. Potato tubers usually are infected at digging time. A dry irregular, spreading, brown, diffuse type of rot develops in storage. On tomato fruits, spots become dark brown, firm, and wrinkled.	Where the disease is present in potatoes and spreading near harvest time, destroy the tops chemically or with a shredder and delay harvesting tubers for at least 10 days.
Tomato	Blossom-end rot	Large, dark-colored, sunken, leathery spot occurring on the blossom end of green or ripening fruit.	Maintain uniform moisture through mulching. Avoid planting tomatoes close to large trees, whose roots compete for moisture.

TABLE VII

Other Vegetable and Fruit Diseases

Crop	Disease	Symptoms	Control
Carrot, Parsnip	Soft rot (Sclerotinia rot)	White mould on roots in storage causing a watery decay. Black fungus bodies develop.	Avoid early digging. Keep storage temperature about 35°F. Pick over before storage.
Carrot, Celery, Parsnip, Potato, etc.	Aster yellows	Outer, older leaves reddish or purple. Younger, central leaves dwarfed, distorted, and frequently very numerous. Numerous branched rootlets growing out from the carrot root.	Leaf-hoppers transmit the disease. Control of weeds is helpful.
Beans	Bacterial blights	Leaves show water-soaked spots becoming brown and brittle. Pod spots are water soaked, later becoming sunken, amber yellow, reddish around the margins. Yellowish spots occur on the seed.	Rotate crops. Use seed from a disease-free crop. Discard discolored seed. Do not sow thickly, and cultivate only when dry.
Peas, Sweet Pea	Seed rot, Root rot	Seed rot indicated by lack of emergence and root rot by reddish-brown decay of base of stem and root. Plants easily pulled up.	Rotate crops and destroy refuse from diseased crops. Use disease-free seed. Treat seed with suitable fungicide to reduce seed rot.
Peas, Beans	Sclerotinia stem rot	Wilting and die-back. Portions of the stems become bleached and shredded. Hard, black fungal bodies (sclerotia) occur inside stem.	Rotate with nonsusceptible crops. Burn all infected plant debris. Control weeds.
Peas, Clover, Raspberry, Gooseberry, etc.	Powdery mildews	Gray to white, powdery spots on leaves and stems.	May be checked by frequent dusting with sulfur. For small gardens place the dust in a cotton bag and shake gently over the plants. Clean up refuse in the fall.
Cucumber	Angular leaf spot	Occurs on leaves and fruits. Water-soaked spots on the leaves develop into tan, angular spots; the centres often drop out, giving a shot-hole effect. Spots on the fruit at first water soaked, later whitish. Fruits may rot.	Clean up and destroy old cucumber vines and debris. Do not save your own seed. Do not plant cucumbers in the same ground more often than once in 4 years.
Apple, Crabapple, Saskatoon berry, Mountain Ash, Hawthorn	Fire blight (See Fig. 46.)	A fire blight effect is produced when blossoms, fruits, leaves, and twigs wilt and turn brown, remaining on the tree. Cankers usually develop in the bark on twigs, limbs and trunks, causing die-back.	Use recommended varieties; they are known to possess some resistance. Prune out and burn all cankers while trees are dormant. Remove blighted twigs as they appear. Make the pruning cut on healthy wood, well below the diseased part. To prevent spread of disease during pruning, dip cutting tools in disinfectant such as 5% formalin or Lysol (1 pint in 4 gal water), 70% denatured alcohol, etc.
Apple, Plum, Crabapple, Rose, Mountain Ash, Raspberry	Chlorosis	Interveinal yellowing and bleaching of the leaves. Quantity and quality of fruit much reduced.	Apply an iron chelate. Acid fertilizers such as ammonium sulphate may help in mild cases.
Raspberry	Mosaic (virus)	Leaves light green or mottled yellow, tending to pucker.	Dig out and burn diseased and adjacent plants.
Raspberry	Leaf curl (virus)	Leaves wrinkled, curled, and darker green than normal.	
Plum	Plum pockets	Affected fruits become puffy, enlarged and bladderlike, at first reddish then powdery gray. Shoots and leaves are often twisted or curled.	Prune back branches severely and spray with lime-sulfur or a bordeaux mixture just before the buds open. Gather and burn affected fruits and twigs.

CROPPING PRACTICES

Efficient production practices are necessary for optimum yields and satisfactory net returns. Accurate records on the farm are the best guide to making decisions on rotations, practices, and the use of capital. Attention must be given to the following:

1. Use and conservation of water; 2. seed-bed preparation and seed placement; 3. control of pests including weeds, insects, diseases; 4. optimum use of fertilizer (see Soils and Fertilizers section); 5. fitting crops to soil and climate; 6. control of soil erosion; 7. analysis of market trends.

MOISTURE USE AND CONSERVATION

The average annual precipitation in much of Saskatchewan is only 15 inches, of which 7 to 8 inches fall in the growing season.

Growing season rainfall is not high enough in most years to grow a satisfactory crop. Stored moisture in the soil should be at least 2 inches in the best moisture areas and close to 4 inches in the driest areas for reasonable assurance of a satisfactory crop.

Research at Swift Current indicates that 10 to 12 inches of water are needed to grow 15 bushels of wheat per acre. Studies by the Research Station at Melfort show a range of 7 to 12 inches of water needed to grow 20 bushels of wheat per acre.

On an average, 1 inch of water will produce 1½ bushels of wheat per acre on Brown soils, 2 bushels on Dark Brown and Thin Black soils, and 2½ bushels on Gray-Black and Thick Black soils. Yields per inch of water will usually be higher under good moisture conditions. The yields per inch of water generally hold only where more than the minimum moisture required to grow some crop is present.

Soils differ in the amount of water they can store. Clay soils may store enough to grow a light crop with very little rainfall. Sandy soils can store little more than the harvest-to-seeding precipitation. The depth of moist soil can be determined by using a soil auger or a spade. Moist soil will cling together in a ball when pressed in the hand. Sandy soils will not form a ball and depth of moist soil can be checked visually or by analysis. Table I shows the depth of moist soil which can be considered minimum for seeding a crop and the depth which can be considered satisfactory.

TABLE I

Satisfactory and Minimum Depth of Moist Soil for Seeding

	Brown, Dark Brown, and Thin Black Soils		Thick Black, Gray-Black, and Gray (Wooded) Soils	
	Satisfactory	Minimum	Satisfactory	Minimum
Sandy Loam	48 inches	40 inches	36 inches	30 inches
Loam	36 inches	30 inches	30 inches	24 inches
Clay Loam	30 inches	24 inches	24 inches	18 inches
Clay-Heavy Clay	24 inches	18 inches	18 inches	12 inches

Summerfallow

Summerfallow is the most important practice for increasing reserve moisture. About 50 percent of the moisture stored in summerfallow is already in the soil in the spring of the summerfallow year. If weeds are allowed to grow too long in the spring, they remove much of the moisture and the surface becomes dry, and is powdered by tillage.

Much of the early spring growth on summerfallow consists of winter annuals. Chemical sprays in the fall will control many winter annuals (see Weed Control section, page 70). If winter annuals are controlled by chemicals, the first tillage on summerfallow can be delayed until other weeds or volunteer grain have started to grow.

Table II shows how yields are improved by starting summerfallow early to control weeds early in the season.

TABLE II

Effect of Date of Starting Summerfallow Operations on Yield of Wheat, Swift Current, 1948-56

Date of Starting Cultivation	Yield of Wheat (bushels per acre)
May 15	24.4
June 1	22.7
June 15	21.9
June 30	20.6

Early tillage on summerfallow has benefits other than weed control. Extended dry periods in May and early June will dry the surface even without weed growth. On burn-out soils such as the Echo and Trossachs or Gray (wooded) soils, early tillage while the soil is moist is needed for surface condition. Where trash cover is heavy, the first tillage is best done before there is any significant weed growth. June rains are often sufficient to delay tillage until green weed growth makes trash management difficult.

Some weeds, such as the winter annual, narrow-leaved hawk's-beard, are not easily controlled by chemical. Where these weeds occur, early tillage is the only satisfactory method of control.

Later work on summerfallow should be designed to keep weed growth down and trash cover at the surface. A good trash cover prevents runoff and reduces evaporation.

Generally, the amount of summerfallow should be based first on reserve moisture and second on weed control requirements and labor distribution.

Sandy soils need special care when summerfallowed because of soil drifting. If these soils have the satisfactory moisture reserve shown in Table I, they should be seeded, provided weed control is satisfactory. Green foxtail and other grassy weeds are usually greater problems in stubble crops than in summerfallow crops, and these weeds are common on a large part of the sandy soils.

On the Black and Gray soils, the need for summerfallow is not as great as on the Brown and Dark Brown soils. Evaporation is lower in the Black and Gray soil regions and more of the total moisture is used by the crop. The northwest part of the province does, however, get less precipitation from September to May than the northeast, and a check on soil moisture reserves is important. If fertility needs on Black and Gray soils are met by the use of legume rotations and commercial fertilizer, summerfallow can be reduced to 25 percent or less of the total crop acreage. On an average, 2-year rotation shows the highest net return on the Brown soils and drier parts of the Dark Brown soils, 3-year rotations on the better moisture areas of the Dark Brown and drier parts of the Black, and 4-year or longer rotations for the thicker Black soils, Gray-Black, and Gray soils.

Table III shows the average wheat yields reported for summerfallow and stubble from 1957-1965.

TABLE III

	Wheat Yields	
	Summer-fallow	Stubble
Crop District 3AN (Brown Soils, Gravelbourg-Elbow)	17.3	10.7
Crop District 2A (Dark Brown Soils, Weyburn)	19.5	13.0
Crop District 6A (Dark Brown to Thin Black Soils Lumsden-Lanigan)	19.8	12.4
Crop District 9B (Black to Gray Soils, Cut Knife-Meadow Lake)	22.6	13.5
Crop District 8B (Black, Thick Black, Gray-Black, and Gray, Humboldt-St. Louis-Melfort)	26.2	17.5

Yields in this table show that stubble yields are considerably more favorable on Dark Brown, Black, and Gray soils than on the Brown. In addition, stubble yields were much higher in the northeast than in the northwest.

Other Moisture Conservation Practices

As the organic matter in the soil decreases, runoff increases. Returning all crop residues to the soil, application of barnyard manure, and grain-forage rotations will help to maintain organic matter and increase water intake. Disc implements and harrows should be used with care. Bare, powdered soil has a high runoff.

Recent experimental work shows that barnyard manure and fertilizer reduce the amount of water needed to grow a bushel of grain. Where moisture is good but a well-seeded crop yields poorly, improvement in fertility and soil condition may be needed. (See Soils and Fertilizers section.)

Regular and timely use of chemical weed control is important. Control of weeds by early spraying saves moisture for the crop, prevents weed seed production, and leaves fewer weeds to kill the following year; fall weed growth is less and fall moisture storage is greater. Chemicals should also be used in the fall to control winter annuals on summerfallow or stubble. Substitution of chemicals for tillage in the fall, and at other times when practical can reduce soil drifting and increase moisture storage. (See Weed Control section, page 69.)

EROSION CONTROL (See Fig. 1, color section, page 84.)

The 15,000,000 or more acres of summerfallow in Saskatchewan each year require careful management to prevent wind and water erosion. Land very subject to erosion should be seeded to perennial crops.

Summerfallow acreage could be reduced considerably by cropping more stubble land when moisture reserves are satisfactory.

Production practices to give high yields are basic to erosion control. A vigorous growing crop, or residues from a heavy crop, provide the best protection against soil erosion.

Where land is very susceptible to erosion, all or most of the following practices are necessary for satisfactory erosion control:

1. Cultivating, seeding, fertilizing for vigorous crop growth; 2. maintenance of trash cover (stubble mulch) on summerfallow; 3. seeding of cereal crops after poor residue crops such as flax, rapeseed, mustard, sunflowers; 4. use of chemicals for weed control; 5. strip cropping and modified contour strip cropping; 6. field shelterbelts (for wind erosion control); 7. permanent vegetation on highly erodible areas; 8. use of grassed waterways; 9. special attention to focal areas of erosion.

Erosion control in Saskatchewan must be based on the use of crops and crop residues. Mechanical control by earth structures or masonry usually involves expensive maintenance under Saskatchewan climatic conditions.

Handling Heavy Straw Cover

Trash cover is the most important single practice for erosion control on summerfallow. Heavy crops, double swaths, and tough straw, such as flax or durum wheat, are difficult to handle. The strawcutter on the combine may cause slower combining but subsequent tillage is easier and cheaper. If the swath is heavy, chopped straw may slow drying of the swath area in spring. A stroke with the cultivator in the swath area or better spreading will allow for earlier spring work. On light crops, it is best to drop the use of the strawcutter as the long straw gives better erosion control.

The oscillating harrow or even the drag harrow will spread straw reasonably well if the straw and stubble are dry.

CROPPING SYSTEMS

The Brown and Dark Brown Soils

Best crop returns on Brown and Dark Brown soils are obtained by modifying crop plans according to moisture reserves. On the better wheat soils the 2-year rotation of grain and summerfallow is satisfactory. In the more moist portions of the Dark Brown soil zone, a 3-year rotation of grain-grain-summerfallow is suitable.

One of the major dangers of increasing stubble crop acreage under less than optimum weather conditions is soil erosion. Light crops on stubble land are often weedy, and straw and stubble are not sufficient to protect the soil. Summerfallow becomes necessary for weed control, and lack of trash cover leads to erodible conditions. A major reduction in summerfallow acreage would also aggravate grasshopper infestations.

Summerfallow, by conserving moisture, helps to insure against crop failure and provides more crop residues for erosion control. Nevertheless the main problem on summerfallow is still the danger of soil erosion. Substitution of chemicals for part of the tillage and using only cultivator, blade, and rod-weeder on summerfallow helps to keep enough trash cover on summerfallow fields.

The use of sunflowers, corn, or other row crops as a summerfallow substitute has doubtful value. They usually result in moisture and fertility variations, and returns from sunflowers are seldom sufficient to balance the reduced yield of the following crop.

While drifting may occur on all soil types in the Brown and Dark Brown zones, the sandy soils and light loam soils are most likely to drift under cultivation. Crops are frequently light and do not compete well with weeds. Intensive tillage for weeds such as quack grass increases the danger of soil drifting. Where weeds can be controlled to allow establishment of a healthy stand of grass or grain, seeding to grass-legume mixtures or continuous cropping is advisable. Fall rye can be used to advantage on sandy soils for fodder production or grain. It is one of the best crops for controlling weeds and soil drifting. At Conquest, on a sandy soil, wheat under continuous cropping has yielded 21 bushels per acre per year compared to 13 bushels per acre per year in a 2-year rotation. This result was obtained in an area protected by shelterbelts.

Clay and heavy clay soils are also susceptible to soil drifting. Lumps or clods on these soils break down very quickly. Trash cover is the most important control, and tillage should be done to keep adequate trash at the surface. Fertilizer and other production inputs will usually produce enough crop on these soils to give sufficient trash for good protection.

On the Brown soils, yields in pounds per acre are highest for oats, followed by barley and wheat. Barley and oats yield about the same on Dark Brown soils, with wheat somewhat less. On the clay soils in both zones, wheat has usually given higher returns than coarse grains.

Fall rye is a valuable utility crop. It is being used for fall and spring pasture, silage or hay, and cash grain. Fall rye is the most practical cereal to follow flax, rapeseed, or mustard on Brown and the drier Dark Brown soils. The

partial fallow provides weed control, increases moisture reserves, and the fall rye crop gives good control of soil drifting in the spring.

Flax has been an important crop in much of the area. The crop does not compete well with weeds. Wild oats and other weeds can be controlled by chemicals. (See Weed Control section, page 72.) Flax stubble gives poor protection against soil drifting. In most areas, flax should be seeded on summerfallow and followed by wheat, fall rye, or other cereal on the flax stubble. In better moisture areas the flax-wheat-summerfallow rotation has given higher returns than wheat-flax-summerfallow, as well as giving better erosion protection on summerfallow. Durum wheat fits well in the flax-wheat-summerfallow rotation and is suited to most of the Brown and Dark Brown soils.

Rapeseed is not well adapted to most of the Brown and Dark Brown soils. It is more suited to better moisture conditions and lower temperatures. Mustard and sunflowers have considerable drought resistance and are better alternatives. These crops all leave poor residues for soil protection. Full information is available in specific bulletins on these crops.

Forage crops and a livestock enterprise should be the basic enterprise on very sandy soils, rolling land, and other land unsuited to grain. Cultivated land in such areas should be used to complement the feed supply as annual hay crops or feed grain. Production of adequate feed for the livestock enterprise will give better long-term returns than cash grain on scattered small parcels of cultivated land.

The Thin Black Soils

The Black soil region has better moisture efficiency than the open prairie and cropping can be more intensive. Summerfallow costs are higher, making returns from longer rotations greater than from the standard 2-year rotation. Summerfallow acreage should seldom be more than one-third of the total.

Wheat, oats, barley, rapeseed, and flax are the best grain crops. Barley and oats yield more pounds per acre than wheat. Fall rye is an important crop on sandy soils and useful for erosion control, weed control, and soil maintenance on these types.

Rapeseed does not yield as high as on the Thick Black and Gray-Black soils. It should be seeded on clean summerfallow and the rapeseed stubble seeded to wheat, barley, or oats.

Mustard and peas are grown in local areas. Except for Black soils in the southeast, climatic conditions are not suitable for sunflowers.

Yields of stubble crops in the Black soil zone can be maintained by the use of commercial fertilizers or commercial fertilizers and legumes. If nitrogen levels are maintained by fertilizers and legumes, the major requirements for high yields on stubble are proper seed placement, phosphate fertilization, and weed control.

Black soils are well adapted to growing forage crops. Use of legumes and grass-legume mixtures for soil improvement is recommended. Forage crops help to control weeds, protect the soil against erosion, provide better soil tilth, and diversify farm income. The better soil tilth allows earlier tillage, and seeding can be done earlier to help overcome the short growing season.

Forage crops are particularly important on sandy soils and on farms with large areas of "bluff podzols." (See Soils and Fertilizers section, page 90.) Forage crops give higher returns than grain on areas of uneven topography, where grain-growing costs are high. The amount of forage sown should depend on feed requirements, soil type, and soil condition. A combination of sweet clover for short rotations and grass-alfalfa mixtures for longer rotations is recommended. This can be developed into a good cropping program for soil improvement and feed production. Several rotations may be in operation on the same farm.

Sweet clover can be used for hay, pasture, seed production, or green manure. If sweet clover is used for seed, summerfallow may be needed the next year. If broken early or worked down early as green manure, sweet clover land can be cropped the next year. Grass-alfalfa mixtures should be left down for 2 to 5 years and rotated with grain. The use of the short-term sweet clover grain along with the longer rotation allows the regular use of legumes on all land.

Results of long-term tests at the Indian Head Experimental Farm show the benefit with grass-legume mixtures in the rotation. Grain yields in the rotation with grass-legume mixtures have tended to increase. In the straight grain rotation, yields are declining and weed control is a much greater problem.

At Yorkton, wheat yields on summerfallow in a 3-year rotation have averaged 22.9 bushels per acre compared with 27.6 bushels per acre in a rotation including grass-legume mixtures.

Recent experimental work at Indian Head has shown the benefits of legumes to stubble crops in the rotation. Land broken from alfalfa-grass mixtures had wheat yields on stubble over 7 bushels higher without fertilizer and over 3 bushels higher with fertilizer than land broken from straight grass.

Gray-Black and Gray Soils

Forage crops should form a definite part of all rotations on Gray-Black and Gray soils. The acreage devoted to forage crops should be at least 25 percent on the better Gray-Black soils. On the sandy soils and some of the poorer Gray soils, forage crops and livestock are the best main enterprise, with forage on 60 percent or more of the crop acreage.

The percentage of wheat in the top grades in Northern Saskatchewan is usually well below the figures for the rest of the province. Barley and oats are better adapted to the growing conditions in most of the area and yield considerably more pounds per acre. The coarse grains also compete better with weeds.

Rapeseed production is well adapted to much of the area, particularly the Polish varieties. Rapeseed straw provides poor residues for erosion control and adds little fiber to the soil. Rapeseed should be followed by cereals in the rotation and should not be grown on the same field more than once in 5 or 6 years. Tests at Melfort and Loon Lake show that wheat and barley yields on rapeseed stubble are very close to yields on cereal stubble. To avoid rapeseed stubble toxicity and to obtain uniform stands on rapeseed stubble, straw should be well spread by straw spreaders and harrows. Adequate fertilizer is also important. (See Soils and Fertilizers section.)

The value of legumes and grasses for Northern Saskatchewan is reported by the Research Station at Melfort. At White Fox, on a fine sandy Gray-Black soil, highest returns were obtained from a long-term rotation of legume-grass and grain, with summerfallow once every 6 years.

On Gray soil at Loon Lake, wheat yielded 5 bushels higher in a legume rotation than in a straight grain rotation over a 4-year period.

Returns increase as the proportion of summerfallow is reduced from 50 percent to 25 percent of the cultivated acreage. Increased returns are, however, entirely dependent on satisfactory weed control, adequate fertilizer, and good seeding practices.

Irrigated Soils

Continuous cropping should be the standard practice on irrigated soils. Rotations should be planned to maintain or improve fertility. Good soil tilth is essential for best water management and maximum efficiency. Consideration must also be given to control of erosion, weeds, plant diseases, and other pests, as well as to even distribution of labor and equipment.

A wide choice of crops can be grown because of the availability of water. Grain and forage crops will be the mainstay of irrigation farming in Central Saskatchewan until markets develop for specialty crops. Summerfallow has

no place in irrigation farming unless weeds become a serious problem or land is being levelled.

Forage crops for hay and pasture should be an integral part of any rotation. Irrigation is most profitable when associated with a livestock enterprise. Pastures can return as much per acre as many of the specialty crops. Alfalfa responds well to irrigation and improves the fertility and physical conditions of the soil. Soils in poor tilth can usually be improved by green manuring with sweet clover or alfalfa. Other crops do well after legumes in the rotation.

Proper irrigation methods are the first requirement. With moisture not limiting, full fertility treatment is necessary for maximum production. Legumes, barnyard manure, and commercial fertilizer should all be used to maintain fertility. Legumes properly fertilized and barnyard manure improve both fertility and soil condition. Barnyard manure should be applied in the fall and plowed in. Manure gives high responses under irrigation, and the highest-price crops should be seeded following its application. (For fertilizer recommendations on irrigated crops, see Soils and Fertilizers section, page 93.)

CULTURAL PRACTICES

Tillage

Tillage accounts for a large part of the total cost of producing crops. Costs can be reduced with suitable implements, proper adjustment, correct speed, and timeliness of operation. Cultivation is required to control weeds, conserve moisture, and prepare seed-beds. Tillage may help to control insects or disease. (See sections on Insect Pests and Plant Diseases.) Excess cultivation, poor machinery adjustment, and high speeds are major causes of wind and water erosion. Experiments show that extra tillage on summerfallow, not required for weed control, does not increase yields.

Maintenance of trash cover is very important. Trash not only protects soil against wind and water erosion but improves moisture penetration and reduces surface crusting on problem soils. Substitution of chemical weed control for one or more tillage operations is an important aid to better trash maintenance. Fall spraying controls winter annuals, and chemical sprays can usually be substituted for at least one tillage during the fallow year at any time when weeds present are susceptible to chemicals. (See Weed Control section.)

Timing is very important on Gray (wooded) or burn-out soils, which have little organic matter. By working these soils at the right moisture content, the tilth is much improved. Working soils of any type when they are very dry tends to cause more powdering.

Summerfallow should be started early in the spring to prevent early weed growth. (See Table II.) Disc implements should not be used on light stubble and should be restricted to necessary trash reduction after very heavy crops. Disc implements bury 50 percent of the trash on each operation, break up soil lumps, and permit drifting, especially when the soil is dry. Drag harrows also pulverize the soil and should be used with caution. Disc implements should be used only for a very heavy straw cover or when wet conditions prevent satisfactory use of cultivator type implements.

Cultivators should be used for most of the summerfallow work. The heavy-duty cultivator has good trash clearance and is adapted to a wide range of shovels. Care should be taken to select the type of shovel best suited to the soil and moisture conditions. (See Agricultural Engineering section, page 14.) The blade cultivator is the best implement for sandy soils in all regions. The field cultivator is a good machine for uniform tillage and surface condition but has insufficient trash clearance for heavy straw and stubble.

The rod weeder combines well with the cultivator on summerfallow. After using the cultivator at 4 inches, the rod weeder can be used for the next, and sometimes the next two operations. The rod weeder is cheap to operate and keeps trash cover at the surface. **The rod weeder should not be run too shallow,** especially for fall work on summerfallow. If run too shallow, it powders the soil and leaves trash loose on top. The flat disc packer pulled behind the rod weeder will help to anchor trash. The heavy-duty cultivator with rod weeder attachment combines the two machines in one. It gives better weed control and leaves more surface trash than the cultivator alone.

Cultivation should normally be from 3 to 4 inches deep on summerfallow. Very shallow tillage gives poor control of perennial weeds and pulverizes the soil. Tillage deeper than 4 inches is costly and usually of little benefit. Very few places in Saskatchewan have any "hard pan" that is improved by tillage deeper than 5 inches. Some variation in the depth of tillage using the cultivator at 4 to 5 inches occasionally will correct most hard layers. Where soil has become very hard, it can best be improved by planting grasses or grass-legume mixtures.

Late fall tillage on summerfallow with a surface already suitable for next spring's seed-bed is justified only for perennial weed control. Winter annuals like stinkweed and flixweed should be controlled by chemical sprays. (See Weed Control section, page 71.) Narrow-leaved hawk's-beard, another winter annual, is difficult to control by chemicals, and fall tillage should be used for this weed.

Stubble land should be worked in the fall only for the following special reasons:

1. Perennial weed control. (See Weed Control section.); 2. insect control. (See Insect Pests section.); 3. reducing excessive trash cover for seeding; 4. improving a puddled or baked surface; 5. incorporation of fall-applied nitrogen fertilizer of weed chemicals. (See Soils and Fertilizers and Weed Control sections.)

Fall tillage does not increase the yield of stubble crops in most areas. The major need is uniform spreading of the trash cover. The oscillating harrow is the best machine to get satisfactory spreading of straw for good seeding management. The use of disc implements on stubble in the fall reduces moisture storage and usually reduces yields. When fall working of stubble is necessary, use the cultivator to leave stubble standing to trap snow. Chemical sprays should be used for winter annuals.

Seeding (See Fig. 2, color section, page 84.)

Use of seed free of disease, mechanical damage, and free of weed seeds is a first requirement. Select good quality, well-cleaned seed. Use Certified seed occasionally to provide seed stock which is true to variety. (See Grain Crops section, page 63.)

Good seed placement is one of the most important elements in satisfactory crop production. Deep seeding produces weak spindly plants and tends to increase severity of common root rot. Slow emergence, due to deep seeding, allows weeds to get ahead of the crop. Seed placed around the 1½-inch depth in firm, moist soil develops a stronger root system than poorly seeded crops.

On loose summerfallow, use the rod weeder or packer before seeding to help firm the seed-bed for better depth control. A well-prepared seed-bed helps to overcome the danger of seeding too deeply and reduces erosion. No method of seeding will produce good results on poorly prepared land. Tillage on summerfallow should be designed to prepare a seed-bed for the following crop.

The value of pre-seeding tillage varies with weed conditions, soil type, and moisture supply. Recent experimental work shows that minimum tillage before seeding gives the highest yields where weed control is satisfactory and seeding is done before the soil becomes dry. When seasonal conditions permit, pre-seeding tillage with a delay to allow one crop of weeds to be killed gives cleaner crops. With good moisture, this has given higher yields but, under dry conditions, the surface becomes too dry for germination. The cultivator, the cultivator and rod weeder, the springtooth harrow, or the cultivator and harrow are best for pre-seeding tillage. The discer is satisfactory where moisture is sufficient and soil drifting is not a problem. **Tillage before**

seeding should be no deeper than the desired depth of seeding. If deeper pre-seeding tillage is necessary, use the rod weeder for firmness and depth control.

The double-disc press drill is the best implement for seeding summerfallow on light, medium-textured, or variable soils. The standard double-disc drill is better for heavy soils where clay sticks to the press wheels. On clay soils, the flexi-coil type of packer will work behind the standard drill. Other packers can only be used a half day or so after seeding when the surface is dry. For firm summerfallow the discer and packer give good results. Packing is very important for good results with discer seeding. V-wheel, sub-surface crow-foot, and flexi-coil packers all give good results but additional weight can be used for loose or dry soil. Experiments at Regina show that pre-seeding tillage may not be beneficial where the discer is used for seeding on clean summerfallow.

The hoe press drill, if properly adjusted, has been found satisfactory on uniform medium- to heavy-textured soils. The rod weeder used ahead of the hoe press drill has improved its operation on other soils. Experimental work at Melfort shows that seeding with the hoe press drill directly into untilled land, followed by the rod weeder, has given the highest yields of wheat, as long as weed control is satisfactory. The seeder attachment on the cultivator works quite well on firm, uniform, medium-textured soils but depth control is difficult on loose friable soils. The rod weeder and seeder combination has given good results on sandy soils and on medium-textured soils. This machine has fairly heavy draft and presents problems under very moist conditions and in heavier soils in depressions.

The harrow is useful after seeding for weed control and some levelling and packing. It does not pack well enough to ensure germination. For most effective weed control, harrow a few days after seeding.

On sandy land, the plow and pony press drill normally perform well. Field results indicate that the cultivator or discer followed by the press drill give almost the same or better yield and are cheaper to use.

To prepare stubble land for seeding, start with uniform straw spreading at harvest time. Where necessary, use the oscillating harrow when the straw is dry, to complete the spreading. A discer or cultivator will work through fairly heavy amounts of straw once it is uniformly spread. If fall tillage is needed, use the heavy-duty cultivator to leave stubble standing. Where crops are heavy, straw chopping is necessary. If the straw must be removed, make every effort to bale it for livestock. Burning straw is a waste and should be done only as a last resort.

Good results have been obtained from the **discer or one-way** in seeding stubble land, but **packing is absolutely necessary.** The hoe press drill gives good results for stubble seeding if straw is light, or chopped and well spread.

Do not waste surface moisture by excessive or deep pre-seeding tillage. Seeding depth for cereals needs to be no more than 1½ inches if the seed is in firm moist soil at that depth. Cereals should not be seeded more than 3 inches deep, flax and rapeseed not more than 2 inches, and forage crops not more than 1 inch deep. Forage crops and grain should, therefore, not be seeded in the same run. For a companion crop, forage should be seeded after the grain crop and at right angles to the grain rows. (See Forage Crops section, page 56.)

Rates of seeding should be based on practice in the local district. The lowest rate can result in good yields, provided weeds are well controlled and there is close to 90 percent germination and emergence. Press-drill seeding usually gives better germination and emergence than the discer. Heavier seeding rates provide better competition with weeds. Optimum seeding rates are as follows, with a range of rates to allow for variability in conditions and seeding machines:

	Brown Soils and Dark Brown (Sandy) to All Clay Loam Soils	Dark Brown (Clays), Black, Gray-Black and Gray Soils
Wheat	45-75 lb per ac	60-105 lb per ac
Oats	50-70 lb per ac	70- 90 lb per ac
Barley	60-75 lb per ac	60- 84 lb per ac
Rye	40-55 lb per ac	55- 85 lb per ac
Durum Wheat	75-90 lb per ac	90-120 lb per ac
Winter Wheat	45-60 lb per ac	—
Flax	28 lb per ac	30- 40 lb per ac
Polish Rape	—	4- 6 lb per ac
Argentine Rape	—	5- 7 lb per ac
Yellow Mustard	7-10 lb per ac	7- 10 lb per ac
Brown and Oriental Mustard	4- 6 lb per ac	4- 6 lb per ac
Peas	—	90-100 lb per ac
Beans	—	90-120 lb per ac
Corn	10-15 lb per ac	10- 15 lb per ac
Buckwheat	—	25- 40 lb per ac
Sunflowers	5- 7 lb per ac	5- 7 lb per ac

Where cereals are used as a companion crop with forage, reduce seeding rates by one-half. (See Forage Crops section.)

Dates of seeding are governed largely by seasonal conditions. Attention must be given to moisture, weed control, crop, soil, and climate in determining seeding dates. Any average date is unsuitable in some years. Delayed seeding is the best cultural practice for controlling wild oats or wild buckwheat, but late seeding usually results in decreased yields. Consideration should be given to chemical control of wild oats or wild buckwheat. (See Weed Control section.) In districts where early fall frost is a hazard, wheat seeding should not be delayed.

Although waiting for the first weed growth has been an accepted approach for the start of seeding, timely use of chemicals for weed control allows earlier seeding. Research at Melfort shows that highest wheat yields on summerfallow are obtained by early seeding with the hoe press drill followed by the rod weeder. Treatments using pre-seeding tillage gave lower yields.

In Southwestern Saskatchewan, yields of oats and barley are normally reduced when seeded after May 10. Barley should be seeded by May 1, or as soon after as possible.

For the Dark Brown soil zone, experiments at Regina indicate that the highest yields result from seeding as early as the land is fit to work, or within 1 week of that date. Oats and barley should be seeded immediately after wheat. Barley can be seeded as late as May 20 in the Regina heavy clay without a reduction in yield; wheat and oats decline in yield as seeding is delayed. Usually flax yields are highest when seeding is between May 16 to 23.

Durum wheat should be seeded as early as possible to ensure maturity.

Over a 13-year period at Indian Head, average yields of wheat were 33.4 bushels per acre seeded May 1; 32.7 bushels seeded May 10; 32.2 bushels seeded May 20; and 28.4 bushels seeded May 31.

Harvesting

Adjustments for harvesting equipment are covered in the section on Agricultural Engineering. (See page 15.) It should be noted, as a guide to the efficiency of threshing, that a loss of only 20 to 25 kernels of wheat per square foot represents 1 bushel per acre.

Swathing wheat should be started when the grain has 35 to 40 percent moisture. Wheat is ready if the kernels are firm but easily dented by the thumb nail. Earlier swathing may be advisable where there is danger of frost or where sawfly damage occurs. To reduce sawfly damage, swathing should begin when infested stems start to break.

Recent work at Swift Current indicates that combining wheat at 35 percent moisture and drying is suitable for commercial grain, but wheat for seed should be allowed to dry in the swath to 20 percent moisture.

Green or damaged kernels cause downgrading of malting barley. Swathing of malting barley may be started about a week before the stage of maturity for straight combining. Combining should be done just as soon as the grain is dry.

For safe storage, threshed grain should not have more moisture than is allowed for straight grades. The highest moisture percentages allowed for straight grades are: Wheat 14.5, durum wheat 14.8, oats 14.0, barley 14.8, rye 14.0, flax 10.5, sunflowers 12.0, and rapeseed 10.5. For extended storage of rapeseed and sunflowers, a moisture content of 9.5 percent is recommended. Complete information on harvesting crops such as flax, mustard, rapeseed, and sunflowers is available from the agricultural representative or research station in your district.

Straw spreaders should be used on the combine unless straw is to be baled for use. For heavy straw, straw cutters should be used. Poor straw spreading results in difficulties during later cultivation. Double swathing has advantages at harvest but causes added difficulty in straw spreading, cultivation, and variable soil condition. The swath should not be laid in the same location at each harvest and extra use of harrows may be needed for adequate spreading.

Sequence of Grain Crops

Barley and oats usually yield better after wheat than does another wheat crop. Barley and oats compete better with weeds, which are a problem on stubble. Experiments at Regina show that wheat after oats yields higher than wheat after wheat either on stubble or summerfallow. Nitrogen-phosphorus fertilizers usually give better responses for barley and oats on stubble than wheat.

On the Black and Gray soils, white-heads caused by "take-all" root rot may become a problem if wheat is grown repeatedly on the same land. Periodic summerfallow or crops of oats, rapeseed, or flax will control the disease. Certain foliage and head disease organisms overwinter on barley, flax, and rapeseed stubble. These crops should not be seeded on the same land 2 years in a row. It is even advisable to arrange rotations so that flax, rapeseed, and barley are not seeded next to stubble of the same crop.

Flax, rapeseed, and mustard are **best grown on summerfallow.** Barley or wheat fertilized according to soil test should be seeded the next year. Some soils such as the calcareous Weirdale and Yorkton associations allow for a firmer seed-bed on stubble and on these rapeseed may be more easily seeded on stubble. If rapeseed is grown on stubble, it should be fertilized. (See Soils and Fertilizers section.) Nitrogen may delay maturity but has given good increases in yield.

Control of winter annuals on neighbouring plots at Swift Current, June, 1965: (a) Cultivated October 16, 1964; (b) no fall treatment in 1964; (c) sprayed with 2,4-D October 13, 1964

Grasses and Legumes in the Farm Program

Forage crops serve a two-fold purpose on the farm. They provide a valuable part of the feed supply for livestock and they maintain the condition of the soil. Thousands of acres of very sandy soil, slightly alkali soil, and rolling land in Saskatchewan would give better returns if seeded to long-term hay or pasture mixtures.

Soil condition is probably a greater problem in Saskatchewan than soil fertility. Better condition or tilth is obtained by using legumes and grass in rotation. Legumes not only build up the supply of organic matter but add nitrogen to the soil. A year's growth of sweet clover may contain as much nitrogen as 10 dollars' worth of commercial fertilizer. Almost two-thirds of this are obtained from the air by root nodules. At Melfort and at a number of experimental project farms in Northeastern Saskatchewan a 3-year rotation of partial fallow-wheat-wheat (seeded to legume) has been compared with a 3-year rotation of wheat-wheat-summerfallow. The average yield of wheat on summerfallow is 3 bushels higher, and on second crop 2 bushels higher in the legume-wheat rotation.

Legumes and grasses will improve many problem soils if a good stand is established. Like other crops, they produce best on good land.

Heavy crops of hay and pasture remove large amounts of nitrogen, phosphorus, and other elements from the soil. More attention should be given to fertility and management of hay and pasture land. (See Soils and Fertilizers section, page 92, and Forage Crops section, page 56.)

Alfalfa and sweet clover are the most important legumes in Saskatchewan. They provide the most nutritive hay and pasture. Alfalfa should generally be grown in mixtures with grass for better production and greater ease of curing. Pure stands of alfalfa are important on irrigated land and on high water table soils, or for the dehydration industry. On very sandy soils, slightly alkali soils, steep slopes, and other problem areas, land should be left in grass-alfalfa as long as production can be maintained. Chemical weed control and fertilizers can maintain production for longer periods than would otherwise be possible.

For best grain yields a full year's summerfallow should be given after sod-breaking. In years of good moisture a partial fallow after taking hay off may be satisfactory.

At Melfort, one of the more moist areas, over an 8-year period, flax, oats, barley, wheat, and rapeseed yielded 14.9, 64.9, 43.0, 24.2, and 16.6 bushels per acre respectively on a grass-legume sod broken July 15 and given only a partial fallow. By applying current prices to the above yields, the highest return crop for sod-breaking can be established.

Wireworms often cause severe damage on sod-breaking. Chemical seed treatment gives good control. (See Insect Pests section.)

Sweet clover is a valuable green manure crop, particularly in the north. It can be used for silage, hay, or pasture. As a green manure crop, it should be worked down with the discer, cultivator, or one-way when it is 10 to 12 inches high. In drier areas, earlier working is necessary to conserve moisture. Sharp discs are needed to work down sweet clover. The heavy-duty cultivator followed by the discer performs well.

Sweet clover produces high yields and is one of the best crops for silage. It is a good short-term pasture. Two or three pounds of grass seeded with the sweet clover will improve quality and hay curing. When yield and price are favorable, fair returns may be obtained from a seed crop. Sweet clover used in any way usually improves soil condition and crop growth.

Forage crops provide the best returns when fed to livestock. Livestock, legumes, and grasses are the basis of the cheapest fertility program. Barnyard manure is not only a good fertilizer but supplies organic matter of the best type for soil improvement. About 70 percent of the phosphorus fed to livestock is recovered in the manure. Other plant nutrients are returned in much the same amount. Over a 29-year period at Parkside on a Black soil of medium texture, barnyard manure applied at the rate of 12 tons per acre every 5 years increased the yield of wheat on summerfallow by 7.3 bushels per acre, and the yield of the second crop wheat by 6.5 bushels per acre. For 11 years at Snowden and 8 years at Star City on Gray (wooded) soil, 12 tons of barnyard manure once in 3 years increased wheat yield on summerfallow by 16.5 and 6.5 bushels per acre respectively. Although increases may not be as great in all cases, barnyard manure is one of the best treatments for unproductive soils. Eroded soils, limy knolls, alkali spots and Gray soils respond the best.

Grass seed production, especially of named varieties, is a profitable secondary enterprise. Nitrogen fertilizer, weed control, and good general management are all needed for high yield. Where livestock are not kept, a short rotation, including sweet clover for soil improvement combined with some areas in grass for seed production, can make a balanced program.

The market for quality hay and for straw from grass seed production has increased in recent years. On the Black, Gray-Black, and Gray soils, hay production can be profitable. Even in the Brown soil zone, well-managed tame hay produced an average of nearly 1 ton per acre from 1943 to 1954.

Recommendations in this section are general. For more detailed information for specific areas, consult your agricultural representative or research station.

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Canada Department of Agriculture

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Soil Erosion by Water. Publ. 1087.
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Saskatchewan Department of Agriculture

Grassed Waterways for Gully Control.
Save the Soil.
Stubble Saves the Soil.
Summerfallow Early.

HORTICULTURE

SHELTERBELTS

Farm shelterbelts protect gardens, soils, crops, livestock, roads, buildings, and people. In cultivated fields, shelterbelts help reduce soil erosion and conserve moisture. Forage, vegtable, oil seed, and cereal crops respond favorably to shelterbelt protection, particularly in dry years. Around the farmstead, shelterbelts reduce home heating costs, control snow drifting, and beautify the farm home. Along municipal and private roads, shelterbelts provide "living" snow fences, as well as food and cover for wildlife.

Source of Tree Material

Tree seedlings for farm shelterbelts are supplied free, except for delivery costs, by the P.F.R.A. Tree Nursery at Indian Head, Saskatchewan. Two-year-old seedlings of six deciduous species, caragana, green ash, Manitoba maple (box-elder), American elm, Siberian elm, and Villosa lilac, and 4- or 5-year-old plants of three coniferous species, Scots pine, Colorado spruce, and white spruce are available. In addition, rooted cuttings of poplar and willow are supplied for use in home shelterbelts, for dugout plantings, and for wildlife habitat projects.

Farmers wanting shelterbelt trees should contact their agricultural representative, or write directly to the Tree Nursery at Indian Head. Applications for trees should be placed as early as possible in the fall or early winter of each year, and all must be received by April 15 to ensure spring delivery. All trees are shipped in late April or early May and are delivered to the nearest agricultural representative's office, or may be picked up at the Nursery.

Selection of Tree Species

Topography, soil, drainage, climate, and the purpose for which the shelterbelt is intended determine which species should be used. Table I provides a general indication of the performance of the various shelterbelt species in three climatic zones (Fig. 1) of Saskatchewan. Local conditions vary widely within each zone and necessitate adjustments. The advice of an agricultural representative or the P.F.R.A. Tree Nursery should be sought if a shelterbelt is to be planted on soils which fail to produce average cereal or forage crops.

TABLE I

Relative Performance of Shelterbelt Species in Saskatchewan Zones

Shelterbelt Species	Climatic Zones and Relative Performance		
	1	2	3
Caragana	Good	Good	Good
Green Ash	Good	Good	Good
American Elm	Good	Good	Fair
Siberian Elm	Poor	Fair	Good
Manitoba Maple	Good	Fair	Poor
Poplar	Good	Good	Fair
Willow	Good	Fair	Poor
Villosa Lilac	Good	Good	Good
Scots Pine	Good	Good	Good
Colorado Spruce	Good	Good	Good
White Spruce	Good	Fair	Poor

Field and Roadside Shelterbelts

Single rows of trees are recommended at intervals of 40 rods (660 feet). North to south hedges generally provide

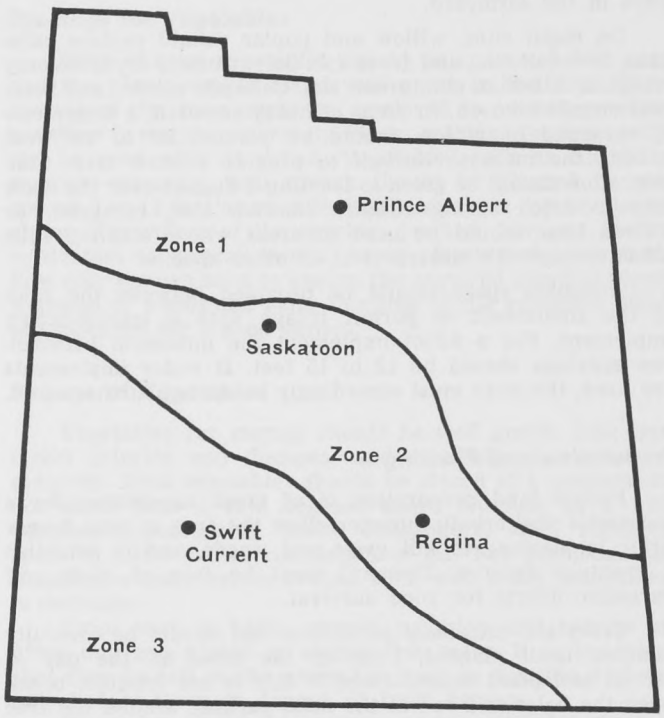


Fig. 1—Zonation map for shelterbelt trees in Saskatchewan

the best protection and encourage even snow melting on both sides of the shelterbelt. Shelterbelts may cause drainage problems on level fields with clay soils unless drainage patterns are well defined. Shelterbelts on fields with rolling topography may create water erosion problems unless properly designed. Obtain the advice of your agricultural representative or soil conservation specialist before planting windbreaks on poorly drained fields or excessively drained fields. Roadside hedges must be planted 150 and 300 feet from the centre of municipal roads and provincial highways, respectively, to comply with regulations. Shrubs such as caragana and lilac should be planted 3 feet apart in field shelterbelts and 2 feet apart in roadside hedges. Deciduous and coniferous trees should be planted 8 feet apart in field shelterbelts and 6 feet apart along roadsides. Green ash, Siberian elm, willow, caragana, Villosa lilac, Scots pine, white spruce, and a combination of green ash and caragana in the ratio of 1.2 are recommended for field shelterbelts; whereas Siberian elm, willow, lilac, caragana, Scots pine, white spruce, and Colorado spruce are recommended for roadside shelterbelts. All species produce shelterbelts with unique characteristics of density, rate of growth, height, width, rooting habit, longevity, and hardiness. Careful selection of the most appropriate species for a particular planting site is required for a trouble-free and effective shelterbelt.

Farmstead Shelterbelts

Three rows of trees, located at least 100 feet from the main buildings, will provide minimum protection for farm buildings and service areas. Additional rows of deciduous and coniferous trees are required to provide complete protection, particularly during winter storms. Under average

conditions, a satisfactory shelterbelt can be developed by planting the outside row to caragana at 2-foot spacings, a second row of green ash, poplar, American elm, or Manitoba maple at 8-foot spacings, and a third row of Siberian elm or willow at 8-foot spacings. Two additional rows of spruce or pine, staggered at 8- to 10-foot spacings and located 25 to 50 feet inside the main belt, can be added to provide year-round protection and beauty to the farmyard. If coniferous trees are desired, the original deciduous shelterbelt must be designed so that the rows of coniferous trees can be planted at least 100 feet from the main building and driveways in the farmyard.

On moist sites, willow and poplar should replace caragana, Siberian elm, and green ash. On extremely dry sites, only caragana, Siberian elm, green ash, Colorado spruce, and Scots pine should be used. In areas of heavy snowfall, a single row of caragana or willow should be planted 50 to 100 feet outside the main shelterbelt to provide a snow trap. Consideration should be given to locating a dugout near the snow trap to catch spring runoff. Siberian elm, caragana, or Villosa lilac should be used in areas where alkaline soils affect the growth and survival of other species.

Adequate space should be provided between the rows of the shelterbelt to permit tillage with a tractor-drawn implement. For a 6-foot implement the minimum between-row spacings should be 12 to 15 feet. If wider implements are used, the rows must accordingly be spaced further apart.

Preparation and Planting

Proper land preparation is of great importance for a successful shelterbelt. Summerfallow the area at least 1 year prior to planting to kill grass and weeds, and to establish a moisture reserve. The soil must be free of clods and excessive debris for good survival.

Trees are extremely perishable and should be carefully handled until planted. Pick up the trees on the day of arrival and plant immediately. If this is not feasible, break open the bales and re-wet the moss packing around the tree roots. Re-wrap the bale and place it in a cool basement or shaded area. If planting cannot be undertaken within 2 weeks after receiving the trees, remove the trees from the bale, dig a trench in moist fertile soil, and carefully cover the tree roots with soil. The trees should remain heeled-in until the following spring when they can be planted in their permanent location.

Trees can be planted by hand or machine. Tree-planting machines are available in many municipalities. When planting, ensure that the trees are planted at least as deep as they were in the nursery and firmly pack the soil around the roots. Do not let the roots dry out prior to and during planting. Watering immediately after planting will usually increase survival and rate of growth, especially for conifer species. Herbicides to control weeds may be applied prior to, or after, planting of the trees. (See Weed Control section, page 75.)

Care of Shelterbelts

After planting, good cultural practices are necessary for favorable growth and survival. Very shallow cultivation of all shelterbelt plantings is recommended for the lifetime of the trees. Deep and close cultivation damages the roots and trunks. Cultivated strips 10 to 20 feet wide should be maintained on both sides of field and farmstead shelterbelts to increase growth and longevity, and to decrease insect and disease problems under prairie conditions. All shelterbelts should be protected by fencing against livestock damage. Pruning should be limited to the removal of dead or broken branches. For best results, replant trees that fail to survive as soon as possible. If using 2,4-D on crops adjacent to shelterbelts, use only the amine formulations and apply with extreme caution.

For control of weeds, insects, and diseases in shelterbelts, consult the following sections: Weed Control, page 75; Insect Pests, page 111; Plant Diseases, pages 120, 125.

VEGETABLE GARDENING

Garden Site

Important points to consider: 1. Steep slopes are undesirable because of excessive moisture runoff and erosion; 2. there should be shelter on all four sides; 3. the site should be convenient to the dwelling; 4. areas free from late spring or early autumn frosts are preferable. Frost damage can be reduced frequently by choosing a site somewhat higher than the adjoining area, and thus providing better air drainage.

Preparation of the Soil

An area twice the size required to produce the vegetables needed in a given year should be set aside in most sections of Saskatchewan. One-half should be summerfallowed each year and the other half cropped. Before summerfallowing, apply from 3 to 5 cubic yards of well-rotted manure per 1,000 square feet. Where moisture conditions are favorable, summerfallowing may not be necessary. In such cases, work in a light application of rotted manure in the fall. Fall cultivation of the garden area is important in preparing a good seed-bed.

Use of Chemical Fertilizers

Many vegetable plants, depending on soil type and particular crop, respond favorably to chemical fertilizer, even when manure has been used. Fertilizers carrying moderate amounts of nitrogen and phosphates are desirable. The fertilizer should be placed in drills at each side of the row about 2 inches from and slightly lower than the seeds. For best results base fertilizer rates on recommendations resulting from soil tests. A suitable rate of application is usually 1 pound of fertilizer to 100 feet of row. The formulation 11-48-0 is recommended for beans, carrots, parsnips, peas, turnips, and other root crops; 27-14-0, 23-23-0, or 16-20-0 is recommended for cabbage, cauliflower, lettuce, onions, sweet corn, and other leaf crops. For tomatoes use 1 teaspoonful of 11-48-0 in a ring around the plant at the time of planting. With corn, poor yields and improper filling can often be prevented by a side dressing of 27-14-0 at 1 pound per 100 feet of row immediately before tasselling. Chemical fertilizers must not come in direct contact with the seed. Where the soil is deficient in moisture, irrigation following seeding will benefit germination and dissolve the fertilizer.

Importance of Good Seed

Seed of high quality is of utmost importance. Seeds carried over from previous years should be tested for germination before being used. Certified seed is recommended.

Seed Treatments

Protection against certain seed-borne diseases, damping-off, and some insect pests is required at planting time. This may be accomplished by seed treatment. (See Plant Diseases section, page 116, and Insect Pests section, pages 109, 110.)

Seeding

Celery, egg-plants, leeks, onions, and peppers should be started indoors about April 1, and broccoli, early cabbage, early cauliflower, and tomatoes about April 15. Plants should be grown in good light and at a temperature of about 65°F so that they will be short and sturdy, rather than tall and

spindly. Plants of broccoli, cabbage, cauliflower, leeks, and onions may be set in the garden before the end of May, but those of celery, egg-plants, peppers, and tomatoes should not be set until all danger of frost is over, unless plant protectors are used. Tall tomato plants, if they must be used, should be set in a sloping position at a normal depth with much of the stem length covered with soil.

Seeds of beet, cabbage, carrot, cauliflower, chard, lettuce, onions, parsnip, parsley, peas, radish, and spinach should be planted outdoors as soon as the ground is dry enough to work in the spring. Beans, corn, cucumber, marrow, melon, pumpkin, squash, and swede turnip, and a second lot of beets and carrots should be sown the last week of May or early June.

Where moisture is deficient, irrigation is desirable following seeding and transplanting. Watering the bottom of the seed trench using a watering can may assure even germination when dry dust falls into the open trench.

Asparagus may be started early in the spring from seed sown in a row at one side of the garden, and the seedlings transplanted 1 year later to a permanent row. A quicker method is to purchase 1- or 2-year-old plants. They should be spaced about 18 to 24 inches apart in the row with the crowns at a depth of 3 to 4 inches.

TABLE II

Some of the More Popular Recommended Varieties of Vegetables

PERENNIALS		
*Asparagus		Viking, Washington strains.
Onions		Chives, Egyptian, White Welch.
*Rhubarb		Canada Red, Early Sunrise, Macdonald.
ANNUALS		
*Beans:	Green-podded	Gardengreen, Slendergreen, Spartan Arrow.
	Wax-podded	Cherokee Wax, Kinghorn Wax, Pencil Pod Black Wax, Round Podded Kidney Wax.
	Broad	Broad Windsor.
	Pole	Blue Lake.
Beet		Detroit Dark Red, Formanova.
*Broccoli		Cleopatra, Early Purple Head, Royal Purple, Waltham 29.
Cabbage:	Early Mid-Season	Canadian Acre, Early Marvel, Golden Acre, Stonehead.
	Late	Bonanza, Danish Ballhead, Evergreen varieties, Penn State.
Carrot		Strains of Chantenay; Gold Pak, Imperator, and Nantes.
*Cauliflower		Snowball strains.
Celery		Cornell strains, Utah strains.
*Corn:	Early	Golden Miniature, Polar Vee, Spancross.
	Mid-Late	Gardentreat, Golden Beauty, McFayden J-6 Cross.
Cucumber:	Table	Marketer, Stokes Early Hybrid, Straight Eight, Supercrop.
	Pickling	Mincu, Morcrop, Spartan Dawn.
Kohl Rabi		Early White Vienna.
Leeks		Champion, Giant Carentan.
Lettuce:	Leaf	Grand Rapids, Simpson's Early Curled, Slobolt.
	Head	New York No. 12, Pennlake, Sweetheart.
*Marrow		White Bush, Zucchini.
**Melon:	Muskmelon	Earligold, Far North, Wheat City.
	Watermelon	Early Canada, New Hampshire Midget.
Onion:	Green	Dutch Sets, Multipliers.
	Bulb: Yellow	Autumn Spice, Copper Gem, Fiesta, Sweet Spanish.
	Pickler	Silver Skin, White Portugal.
Parsnip		Guernsey, Short Thick.
*Peas		Lincoln (Homesteader), Selkirk.
**Peppers:	Sweet	Earlired, Harris Earliest, King of the North, Vinedale.
Potato:	Early: White	Warba.
	Red	Red Warba, Viking.
	Main Crop: White	Irish Cobbler.
	Red	Norland.
	Russet	Netted Gem and Columbia Russet—late, but often do well under irrigation or where the natural moisture supply is good.
	Late Blight Resistant	Cherokee (white), Kennebec (white).
Pumpkin		Early Cheyenne Bush, Jack-O-Lantern, Sugar.
Radish:	Round	Champion, Cherry Belle, Comet, Stop Lite.
	Long	Icicle.
*Spinach		King of Denmark, Long Standing Bloomsdale.
Squash:	Summer	Crookneck.
	Winter	Buttercup, Golden Hubbard, Golden Nugget, Kindred, Perfection.
*Swiss Chard		Fordhook Giant, Lucullus, Rhubarb (red).
Tomato:	Bush type: Standard	Bush Beefsteak, Manitoba, Meteor, Rocket, Swift.
	Hybrid	Bountiful, Mustang.
Turnip:	Swede	Laurentian.

*All varieties with an asterisk are suitable for freezing.
**Plant protectors or plastic mulch required.

Rhubarb should be started from divisions, each having two or more strong buds. Planting in the spring is desirable. The plants should be set 4 feet apart in the row with the crowns about 1 inch below ground level.

Varieties of Vegetables

It is important to use recommended varieties of vegetables. Some of the more popular varieties are given in Table II.

Spacings for Vegetables

Rows of most vegetables should be at least 3 feet apart and the plants should stand well apart in the row. Wider spacing of the rows might be employed to advantage where moisture is scarce; conversely, closer spacings for some crops can be used with irrigation. Vegetables such as cucumber, marrow, pumpkin, and squash should be planted in rows spaced 8 to 12 feet apart, although bush types can be planted closer. Regardless of the spacing, practise frequent shallow cultivation to destroy weeds. Avoid planting close to trees. Sow only enough seed to ensure the required stand of plants. Removal of weeds and early thinning of the vegetable plants are essential for a good garden.

Storage of Vegetables

Vegetables for storage should be well grown, free from insect injuries and diseases, and carefully harvested at maturity. Most vegetables should be stored at a temperature not more than a few degrees above freezing in a well-ventilated, reasonably moist atmosphere, with sufficient space to allow a free circulation of air. For pumpkins and squashes, a temperature around 50°F with a dry atmosphere is desirable.

Crops such as beets, carrots, parsnips, and turnips are often dug and placed in storage too early. It is important that they be left in the ground as long as possible, and dug only before there is danger of frost damage.

Plans for basement storage rooms may be obtained from your nearest agricultural representative, experimental farm, or research station.

POTATOES

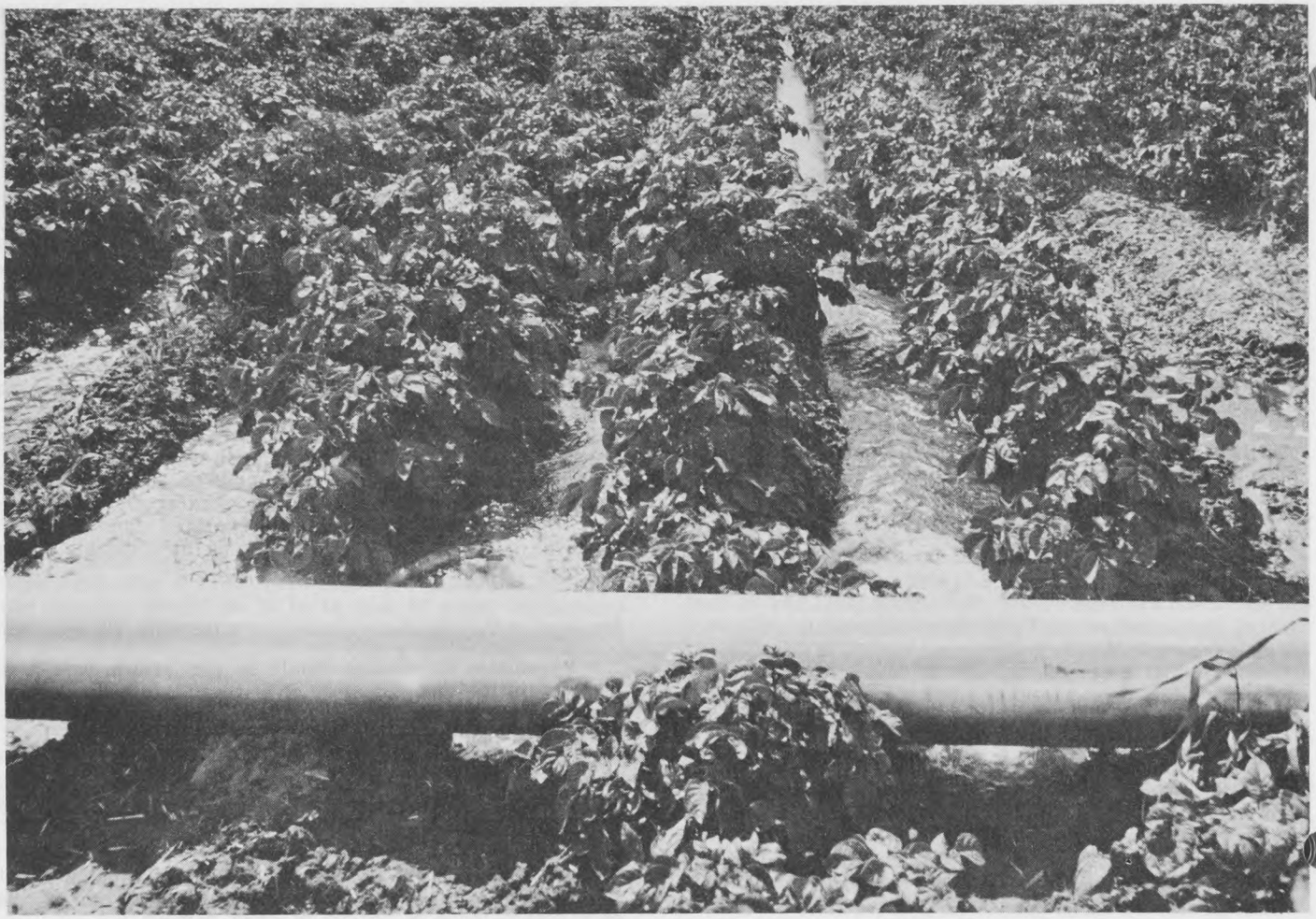
Commercial Production

There has been some degree of commercial vegetable production in Saskatchewan for many years. The South Saskatchewan River Irrigation Project now has the potential for large acreages of a rather wide range of vegetable crops, including beans, beets, cabbages, carrots, cauliflowers, onions, parsnips, peas, potatoes, rutabagas, and sweet corn. The main limiting factor at the present time is the lack of an adequate market, with the result that the only appreciable acreage to date is that of potatoes.

Varieties

Netted Gem—This has long been the most important main-crop variety in such potato-producing areas as Alberta, Manitoba, and Idaho. The tubers are oblong in shape with netted skin and shallow eyes. Netted Gem is resistant to common scab. This variety has above-average dry matter, is exceptionally good for baking and French frying. Processing qualities (granules and flakes) are very good and it keeps well in storage. It is most suitable for production on light soils under irrigation. Netted Gem is a late variety and requires a long growing season to reach maximum maturity and quality.

Norchief—This is a bright red, mid-season, high-yielding variety with uniform, attractive tubers. This variety has had a tendency to set rather heavily, resulting in a number of undersize tubers at standard plant spacing.



Irrigating potatoes by the furrow method using gated pipes. Timely irrigation of potatoes can boost yields to more than 15 tons per acre.

Norgold Russet—This is more of a mid-season variety with oblong, smooth, netted tubers of attractive appearance. Norgold Russet is 2 to 3 weeks earlier than Netted Gem and tubers are blockier in shape. The yield of marketable tubers is high and culinary qualities are good. It is resistant to common scab, but is susceptible to hollow heart.

Norland—An early-maturing variety that is a few days later than Warba. The tubers are oblong with smooth, reddish skin and shallow eyes. This variety produces a high percentage of marketable tubers of fair to good quality. In some seasons in some localities after-cooking darkening can be a problem. Norland shows some resistance to common scab.

Red Warba—Is identical to Warba in all respects except for skin color.

Viking—This is a mid-season variety in maturity, but it sets tubers early. The oblong, smooth tubers have a dark red skin and shallow eyes. Viking has good boiling and baking quality, but is not a good chipper. Close spacing is recommended as the tubers tend to oversize and are subject to cracking.

Warba—The earliest variety available. Tubers are roundish, with white skin and pink eyes. Warba is a good yielder and usually produces a high percentage of marketable tubers but, due to deep eyes, it is confined to early use. The flesh is white and has good boiling qualities. It is susceptible to common scab.

Seed-Handling Practices

The regular purchase of Foundation or Certified seed is an excellent practice. Just as important as quality seed stocks are the handling techniques used.

Tubers should be cut into blocky seed pieces of 1½- to 2-ounce size. Chips and slivers below 1 ounce should be separated out and discarded in order to reduce the number of weak plants in the field. A 38-inch row spacing and 12- to 15-inch spacing in the rows requires between 19 and 28 bushels of seed per acre.

Seed potatoes should be hauled, stored, and handled with equipment that has been thoroughly cleaned and disinfected. Quaternary ammonium compounds are ideal for this type of disinfection.

Where practical, seed potatoes should be warmed up prior to cutting so that short, thick sprouts develop. While the potatoes are being cut, a regular disinfection of cutting and handling machinery is recommended. Where cut seed is not planted immediately, very specific conditions for storage must be provided:

1. Use a dust type of seed treatment; 2. use forced air circulation through the pile; 3. hold at a temperature of about 60°F and a relative humidity of 85 to 95 percent for at least 3 days; 4. after the curing period, maintain humidity, but reduce the temperature. Air flow may be reduced by operating the fans intermittently.

Seed Treatment

The treatment of cut seed, if properly done, will help assure a good stand of plants in the field by helping to prevent seed-piece decay and infection by such diseases as blackleg. Surface infections of scab and rhizoctonia will be controlled by seed treatment, but internally borne diseases will not be affected.

1. **Dry Treatment**—Apply such materials as Polyram, Captan, or Dithane M45 according to manufacturers' recom-

mendations. The application machinery should provide a uniform coverage of dust over the surface of the cut tubers.

2. **Wet Treatment**—Apply Semesan Bel, Captan, or other materials as directed. Unless extreme care is taken, cut potatoes will not store after wet treatment, especially when Semesan Bel is used. Immediate planting is recommended.

Fertilizer

Application of fertilizer should be made on the basis of a soil sample which has been analysed by the Soil Testing Laboratory, University of Saskatchewan, Saskatoon. Fertilizer (particularly the phosphorus portion) should be applied in bands 1 inch below and 2½ inches to each side of the seed-piece. Broadcast applications of nitrogen are acceptable. It is recommended that the soil test reading for N plus the N added should total about 150 pounds per acre. Likewise, the soil test reading for P, plus $P_2 0_5$ added should be about 75 pounds per acre. At the present time there appears to be no need to add any $K_2 0$ or any of the micro-nutrients.

Planting

Planting dates may vary in Saskatchewan from early to late May, depending upon the climatic conditions in a given year, the variety and the purpose for which the potato crop is being grown. Potatoes should be planted as early as conditions will permit, but soil temperature should be at least 40°F. Cold or wet soils should be avoided if possible, as seed-pieces will be subject to rot, and this will result in poor plant stands.

Most potato planters are constructed with a row spacing of 38 inches. The seed-pieces may be placed anywhere from 9 to 15 inches apart in the row. Close spacing is required for some varieties to prevent oversizing, growth cracks, or hollow heart. Under optimum conditions, a close spacing will result in higher yields.

The picker-type planter is the most common type presently being used in Saskatchewan. The assisted-feed type requires more labor, but also is much less apt to spread disease from one seed-piece to another. This latter type would be more desirable for the grower of Foundation seed.

No specific depth of planting will give equally good results under all conditions. Planting depths of 3 to 5 inches are in common use, but it is very important for good germination to place the seed in warm, moist soil. Shallower planting is favored where rhizoctonia has been a problem, as quick emergence reduces the possibility of infection.

Insects

The most important insect pests of potatoes in Saskatchewan are aphids, Colorado potato beetles, leafhoppers, and wireworms.

Because chemical controls are changing rapidly, the current issue of the Saskatchewan Department of Agriculture Publication No. 625, "Chemical Control of Insects," should be consulted for control measures.

Diseases

The potato is subject to many diseases, and therefore the grower must practise disease prevention at every stage of his potato operation in order to make it profitable. (See Plant Diseases section, page 125, for latest control measures.)

Losses from soil-borne diseases such as blackleg, common scab, rhizoctonia, and verticillium wilt can be greatly reduced by planting a particular field to potatoes only once in 4 years. The organisms causing bacterial ring rot, early blight, and late blight will survive on potato debris in the soil only until such debris has decomposed in the following year. Diseased seed tubers are the major source of infection, for several important diseases. The viruses causing leaf roll, spindle tuber, and several mosaics; the fungi causing late blight; and the bacterium causing bacterial ring rot are carried from one crop to the next mainly in planting stock. Some of these pathogens may also be carried from diseased to healthy tubers by a contaminated cutting knife or planter, thus increasing the disease potential before the crop is planted. Therefore, seed stocks should be carefully selected to assure that they are free from tuber-borne diseases.

Certain viruses are carried from diseased to healthy plants by aphids or leafhoppers. Control of these insects may reduce the spread of these viruses, but planting of "virus-free" seed stocks is the most important way to prevent serious losses. The mosaic viruses and bacterial ring rot can be spread to healthy plants by cultivating and spraying equipment that bruise the growing potatoes and allow the disease organism to get into the wounded tissue. A strong, healthy plant properly supplied with nutrients and moisture is a good defense against disease during the growing season.

Several important potato diseases may show up in storage. Losses from storage rots can be reduced by avoiding mechanical damage to the tubers at harvest and by storing them for the first month at 45° to 55°F with a relative humidity above 90 percent to allow wound-healing to occur. Storage temperature should then be lowered to 40°F for the remainder of the storage period. Potatoes harvested in hot weather are susceptible to severe breakdown from leak. These potatoes should be immediately stored at 40°F or lower and marketed as soon as possible.

Weed Control

A good degree of weed control can be obtained by preparation of a desirable seed-bed and, of course, by not allowing weeds to go to seed in the rotation crop. Herbicides have proven to be a valuable supplementary measure, but should not be considered as a substitute for the use of good husbandry practices in potato production. The reader should refer to the Weed Control section of this **Guide.**

Cultivation

The basic reasons for cultivating potatoes are: 1. Control of weeds; 2. soil aeration and maintenance of soil tilth; 3. hilling the plants just prior to blossom time. Several types of cultivators have been successfully used for shallowly cultivating and hilling potatoes, including disc, sweep, and the newer rolling-cultivator types. Hilling will smother small weeds in the rows and will protect tubers from sunburn and fall frost damage.

Irrigation

Water may be applied by either furrow or sprinkler methods, so long as it is applied when needed and in sufficient quantities to wet the entire root zone. Soil moisture levels should be maintained at least above the 50 percent level of field capacity and preferably above 70 percent. Irrigation should start before the soil becomes dry enough to retard growth and before the leaves of the plant become dark. Frequent irrigations should be the objective in order to keep the soil moist. Irrigation should be stopped when the tubers are nearly large enough, in order that the plants may more readily mature. It may be necessary to irrigate again shortly prior to harvesting to prevent undue trouble from large clods and lumps.

Harvesting

Vines on most varieties need to be killed artificially 10 to 14 days before the desired harvest date. This hastens maturity and reduces skinning during harvesting. Use a slow kill to encourage a maximum dry-matter content in

the tubers and to reduce the possibility of causing stem-end discoloration. Such chemicals as diquat (Reglone), dinoseb (a dinitro), and sulfuric acid may be used as vine killers. Follow directions on the container.

Even when the skins are fully "set" on the tubers, they should be handled with extreme care, as potato tubers bruise easily. The speed of the conveyor chain and the amount of soil brought up should be so regulated that a cushion of soil remains with the tubers at least three-quarters of the way up this chain. All sharp edges and corners on the harvester should be padded with rubber. The maximum height of drop of the tubers, from the time they are taken out of the ground until they are placed in storage, should be 6 inches.

Storage

It is extremely important that potatoes be "cured," "healed over," or "corked over" during the first part of the storage period. This new, protective "skin" over minor wounds helps to protect the tuber from invasion by decay-causing organisms, and to reduce further moisture loss.

After curing, potatoes which are to be removed from storage before mid-December should be held at 45°F to prevent sugar buildup. The same temperature can be used for stocks held longer provided: 1. Appropriate sprout inhibitors have been used; 2. proper airflow is provided; 3. correct humidity is maintained.

Where these conditions cannot be met, potatoes should be cooled to 40°F and held at this temperature. Relative humidity should be kept above 90 percent at all times. If potatoes have been stored near 40°F, they should be warmed to a temperature of 45° to 50°F before they are removed from storage. Potatoes to be used for chips and French fries have special storage requirements to lessen their susceptibility to handling damage. At temperatures below 45°F, sugars in the tuber tend to build up, causing a dark color in the processed product. This is particularly true in the frying of the Saratoga chip. Chipping potatoes are commonly reconditioned at 60° to 70°F for 2 to 4 weeks if they have been stored below 50°F. Sprout inhibitors should be used on potatoes stored for processing.

Adequate ventilation through the pile of potatoes is essential in order to prevent a condition of anoxia, with resulting Black Heart. If the potatoes are muddy at harvest time (a wet fall), take special care to distribute them across the bin with the bin loader in order to prevent an accumulation of soil in the middle of the bin that will effectively prevent a flow of air up through the pile.

Sprout Inhibitors

Year-round marketing of potatoes has become a reality with the development of effective sprout inhibitors. In addition, processors are able to use stored potatoes over a longer period of time (potentially from one crop seasen to the next) with little or no loss from sprouting. The two chemicals presently in use are maleic hydrazide (MH-30) and C.I.P.C. Maleic hydrazide is applied as a foliar spray about 2 weeks after full bloom. C.I.P.C. is normally applied as a fog within the storage bin after the curing or suberization period, or it can be applied as a spray on the grading line following washing. The latter procedure of course will only prevent sprouting from this period in time onwards.

FRUIT GROWING

Varieties and Zones

The need for hardiness, drought tolerance, and early maturity places the choice of varieties in fruits next to shelter in importance. The Prairie provinces have been zoned for suitability of fruit varieties. (See Fig. 2.) Certain special areas will be found within each zone. The variety ratings given in Table III are for the zones as a whole. Detailed information on fruit growing is lacking for Zones 6A and 6C.

Planting Site

A site similar to that outlined in the section on vegetables is desirable. A very gentle slope towards the east or north is considered the best. Shelter is of prime importance and should be provided on all sides.

Fruitfulness

All named varieties of apples, apple-crabs, crabapples, cherries, and plums are, for all practical purposes, self-unfruitful. Plants of at least two varieties of the same kind of fruit are necessary for fruitfulness, and three or four varieties are preferable. The hybrid plums listed are not sufficiently fertile among themselves to be grown successfully alone, but are fertilized by the native plums listed. Varieties of the same kinds of fruits should be planted near one another to provide favorable conditions for cross-pollination.

Propagation of Fruits

The beginner is cautioned against starting with anything other than named varieties, and these are not to be confused with seedlings of named varieties. Named varieties of our common hardy fruits do not come true-to-variety from seed. Increases in them must be made through budding, grafting, and layering, as well as through the use of cuttings, runners, and suckers.

Plants

Strong, healthy plants are desirable. In tree fruits, either 1- or 2-year-old plants are recommended. Older trees, when of normal size for their age, are more difficult to transplant than younger trees.

Planting

For all except the strawberry, planting in early spring when plants are dormant is desirable. The setting of strawberry plants can frequently be delayed to advantage until some growth has occurred. The roots of fruit plants must not be allowed to dry out during handling and planting. The soil should be firmed around the roots of newly set plants and a watering given after planting. A slight depression left around the base of the plant is advantageous, except with strawberries, where soil washing into the depression might cover the crown and smother the plant.

Pruning

Plants of crabapples (apple and apple-crabs), cherries, plums, and sandcherry plum hybrids should be cut back to within 12 to 15 inches of ground level immediately after being planted. One year later, branches produced from the stub should be thinned to five in number. These should be uniformly spaced and should be cut back to one-third their length.

Plants of currants and gooseberries should be cut back to within 3 or 4 inches of the ground at planting time, and those of the red raspberry from 12 to 18 inches of ground level. Raspberry, currant, and gooseberry plants must be pruned correctly, annually, if good crops of fruit are to be obtained. The red currant, white currant, and gooseberry, for the most part, fruit on spurs produced on 2-year-old wood. Thus, the normal practice is to spring-prune all wood older than 3 years right back to the crown to force replace-

TABLE III

Behavior of Selected Varieties of Fruits in Zones in Saskatchewan

KINDS	VARIETIES	ZONES 2A	3B	4	4A	5	6A	6C
Apple	Goodland 4-4-3	–	S	T	T	T	–	–
	Harcourt 4-4-1	–	S	S	T	T	–	–
	Heyer 12 4-1-0	S	S	S	S	S	T	T
	Heyer 20 4-1-0	S	S	S	S	S	T	T
	Patterson 4-4-3	–	T	S	F	F	–	–
Crabapple	Dawn	–	S	S	S	S	–	–
	Dolgo	S	S	S	S	S	T	T
Apple-Crab	Kerr	T	S	S	T	S	T	T
	Rescue	S	S	S	S	S	T	T
Plum: Native	Bounty	S	S	S	S	S	T	T
	Dandy	S	S	S	S	F	T	T
Hybrids	Patterson Pride	T	F	S	F	F	–	–
	Pembina	T	S	S	F	S	T	T
	Prairie	T	S	S	F	F	–	–
Salicina	Ivanovka	T	S	S	F	F	–	–
	Ptitsin No. 5	T	S	S	F	F	–	–
Sandcherry x Plum	Dura	S	S	S	F	F	T	T
	Manor	S	S	S	F	F	T	T
	Opata	S	S	S	S	S	T	T
Cherry: Nanking	Selected Seedlings	T	S	S	T	S	T	T
Sour (P. fruticosa)	Selected Seedlings	T	S	S	T	S	T	T
Red Raspberry	Boyne	–	S	S	S	S	–	–
	Chief	S	S	S	S	S	–	–
Strawberry: June-Bearing	*Porter's Pride	S	S	S	S	S	T	T
	*Redcoat	S	S	S	S	S	T	T
Ever-Bearing	*Parkland	T	T	T	T	T	T	T
	*Superfection	T	T	T	T	T	T	T
Currant: Red	Red Lake	S	S	S	S	S	T	T
	Stephens	S	S	S	S	S	T	T
White	White Grape	S	S	S	S	S	T	T
Black	Magnus	S	S	S	S	S	T	T
	Willoughby	S	S	S	S	S	T	T
Missouri	Selections	S	S	S	S	S	T	T
Gooseberry	Pixwell	S	S	S	S	S	S	T
	Thoreson (Pembina Pride)	S	S	S	S	S	S	T

* = Requires Winter Covering. T = For Trial Only.
F = Fair. – = Information Lacking.
S = Satisfactory.

4-1-0, 4-4-3, etc., are an attempt to denote quality. The rates are out of 5 and the first number denotes cooking quality, the second, the quality of the raw fruit for eating out of hand, and the final figure the storage life of the fruit.

ent branches. Black currants, on the other hand, fruit on wood produced the previous season, and all such wood after fruiting should be cut back to the crown the following spring. The raspberry also fruits on the previous season's wood, and canes should be cut back to ground level immediately after fruiting.

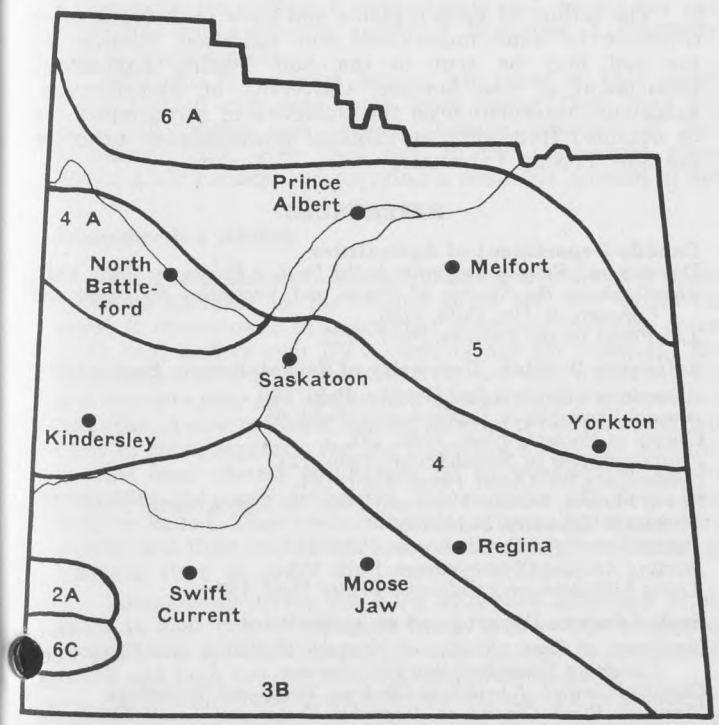


Fig. 2—Zones for fruit varieties

Winter Protection

Strawberry plants should be mulched with slough hay or clean, coarse straw soon after the ground becomes frozen. The mulch covering strawberries should be removed in the spring before appreciable growth takes place.

Protection of Horticultural Plants Against Pocket Gophers

For control of pocket gophers see University of Saskatchewan Extension Division Publication No. 192, entitled "Control of Pocket Gophers."

Honeybees and Fruit Growing

Cross-pollination is necessary if certain kinds of plants are to be fruitful. Although other insects help transfer pollen, the honeybee is one of the best carriers and its presence does much to ensure proper pollination. One good colony of bees is ample for a fruit plantation of 2 acres. If there is a shortage of honeybees in the district, farmers growing fruit should seriously consider keeping a colony or two.

ORNAMENTAL GARDENING

Some attention should be given to beautifying the home grounds beyond that of planting trees primarily for shelter. Beautiful grounds are uplifting to the community and a joy to possess, and they should be regarded as an essential part of the home.

The home grounds should be laid out according to a definite plan that embodies both utility and beauty. Provision should be made for a lawn and for the use of ornamental shrubs, flowers, and specimen trees. Overly ambitious plans should be avoided. A simple plan which fits into the natural landscape is best. A small area, well kept, is preferable to a larger area partially neglected.

Only hardy, drought-tolerant, and tried planting materials should be used. Certain native shrubs can often be used to advantage. Both annual flowers and perennial flowers are recommended. In annuals, those that can be started outdoors are usually more desirable for use on the farm than those that must be started indoors. However, when established, many of the latter may have a longer season of bloom.

Annual Flowers

Lower-Growing—California poppy, candytuff, clarkia, dwarf marigold, dwarf nasturtium, godetia, love-in-a-mist, mignonette, portulaca, scarlet flax, sweet alyssum, and Virginian stocks.

Taller-Growing—amaranthus, annual baby's breath, black-eyed susan, Chinese houndstongue, corn flower, cosmos, larkspur, lupine, marigold, nicotiana, salpiglossis, scabiosa, Shirley poppy, sweet sultan, zinnia.

Climbers—morning glory, nasturtium, scarlet runner bean, sweet peas.

A few outstanding annuals and others treated as annuals grown from seed usually sown indoors late in March and obtainable in considerable variety are: bedding dahlia, dianthus, lobelia, pansy, petunia, phlox, salvia, snapdragons, stocks, verbena.

Tender perennials grown as annuals and having outstanding merit are dahlias and gladioli.

The following should not be grown: "Wild Flower Garden Mixtures," kochia, and perennial snapdragon.

Perennial Flowers

Lower-Growing—alyssum, Carpathian harebell, coral lily, dwarf iris, dwarf veronica, grass pink, Haage campion, Iceland poppy, maiden pink, rock-cress, rock saponaria, snow-in-summer, sweet william, Thunberg's lily, tulips.

Taller Growing—baby's breath, Brandon pink coral bells, Chimney bellflower, columbine, daylilies, delphinium, German iris, golden glow, golden marguerite, Lanceleaf thermopsis, hardy lilies, lythrum, peonies, pyrethrum, Scarlet lychnis, Siberian iris, Spike speedwell, sweet rocket.

Chrysanthemums and fall asters of the hardy, early-flowered types are also being grown with considerable success in certain areas.

Named varieties of daylilies, iris, lilies, lythrum, peonies, and tulips cannot be successfully grown from seed, and must be propagated by divisions.

Woody Plant Material

Low-to-Medium Deciduous Shrubs—cherry prinsepia, Clavey's dwarf honeysuckle, dwarf euonymous, European cotoneaster, Globe caragana, Meyer lilac, Missouri currant, Oriental spirea, Peking cotoneaster, Pikow spirea, pygmy caragana, roses (Assiniboine, Betty Bland, George Will, Hansa, Harison's Yellow, Persian Yellow, Scotch, Stanwell's Perpetual, Therese Bugnet, Wasagaming), Russian almond, shrubby cinquefoil, sweetberry honeysuckle, threelobe spirea.

Tall Deciduous Shrubs—Amur maple, buffaloberry, common caragana, French lilac, highbush cranberry, Tatarian honeysuckle, Hungarian lilac, hybrid lilacs, Korean lilac, Lorberg's caragana, pincherry, plum, redosier dogwood, salt tree, saskatoon, Siberian dogwood, Sutherland caragana, Tidy caragana.

Evergreen Shrubs—Brandon cedar, Canby pachistima, creeping juniper, Golden Pfitzer juniper, Mugo pine, Rocky Mountain juniper, Savin juniper, Ware's cedar.

Low-to-Medium Hedges—cherry prinsepia, Globe caragana, Nanking cherry, Peking cotoneaster, pygmy caragana, shrubby cinquefoil, sweetberry honeysuckle.

Medium-to-Tall Hedges—Amur maple, Colorado spruce, common caragana, Siberian elm, nonsuckering lilacs, white spruce.

Woody Climbers—Chinese clematis, Virginia creeper, Western virgin's bower.

Small Deciduous Trees—flowering hawthorn, mountain ash, rosybloom crabapples, Schubert chokecherry, Tatarian maple.

Large Deciduous Trees—American elm, Amur chokecherry, birch, bur oak, green ash, Manitoba maple, mayday tree, Siberian crabapple, Siberian elm, Siberian larch, Siberian white willow.

Evergreen Trees—alpine fir, Colorado spruce, Scots pine, Swiss stone pine, white spruce.

LAWN MAKING

Lawn grasses recommended for the prairie area of Saskatchewan are classified according to their moisture requirements. Kentucky bluegrass and creeping red fescue are recommended for watered lawns; Russian wild ryegrass, Streambank wheatgrass, and Sheep's fescue (hard fescue) are recommended for unwatered lawns. In the Parkbelt, this distinction is not so important and Kentucky bluegrass usually does well, even if supplementary water cannot be provided.

Preparation of Lawns

At least 4 to 6 inches of fertile topsoil is desirable to grow good grass. When grading, be sure to remove the topsoil so that the levels can be established on the subsoil before the topsoil is returned. Summerfallowing or chemicals will rid the area of annual weeds and grasses. If chemicals are used, they should be applied 1 year before seeding.

Well-rotted manure or peatmoss benefits a lawn but should be thoroughly broken up and mixed into the soil. A rototiller is ideal for this. A slight slope (approximately 1 percent) should be established away from buildings, walks, and drives. Then to get the area uniformly firm, the surface should be smoothed and packed by a hand roller and a rake or by a packer and harrow. This will prevent small depressions and humps later when the lawn is watered or heavy rains occur.

Commercial fertilizer (16-20-0) at the rate of 5 pounds per 1,000 square feet can be applied and worked into the soil a few days before seeding.

Seeding

Recommended seeding rates are 4 pounds of Kentucky bluegrass or 5 pounds of creeping red fescue per 1,000 square feet. The 5-pound rate is also used for Russian wild ryegrass and Streambank wheatgrass. In barnyards, however, the rate could be reduced to 40 pounds per acre. The rates are based on the use of good seed. New crop seed is desirable in the fescues, as this seed often deteriorates rapidly. In most of Saskatchewan, the best time for seeding is during the latter part of May, early in June, or in the last 2 weeks of August. Seeding should be avoided during the hot, dry months, unless artificial watering is possible. On small areas, the seed can be raked in and lightly covered with a garden rake. On large areas, it can be sown with a seed-drill. Where watering is possible, the surface soil should be kept moist after seeding until the grass appears.

Fertilizing the Lawn

Where water can be supplied artificially, good results are usually obtained from an application of ammonium nitrate phosphate (27-14-0) at the rate of 5 pounds or ammonium phosphate (16-20-0) at the rate of 7 pounds per 1,000 square feet of lawn surface soon after growth begins in the spring. The fertilizer should be broadcast evenly when the grass is dry, and watered immediately following application. Three applications per year are desirable at approximately 6-week intervals beginning soon after growth begins in the spring. Where artificial waterings are not possible in the prairie area, an application of fertilizer in either October or early spring is all that is recommended.

Diseases of Lawns—See Plant Diseases section, page 120.
Weed Control in Lawns—See Weed Control section, page 75.

SOIL TESTS

The failure of garden plants and trees to thrive is often traceable to some undesirable soil condition. Samples of the soil may be sent to the Soil Testing Laboratory, Department of Soil Science, University of Saskatchewan, Saskatoon. Information on the collection of soil samples can be obtained from your agricultural representative office or the Soil Testing Laboratory.

REFERENCES

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Handbook on the Storage of Fruits and Vegetables for Farm and Commercial Use. Publ. 1260.
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Extension Division, University of Saskatchewan Saskatoon

A Gardener's Guide to Soil Fertility. Publ. 189.
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Fruit Gardening in Saskatchewan. Publ. 123.
Landscaping the Urban Home. Publ. 173.
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Starting Annual Plants Indoors. Publ. 153.
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Saskatchewan Department of Agriculture

Catalogue of Plans, Fruit and Vegetable Buildings and Equipment. Canadian Farm Building Plan Service.
Chemical Control of Insects in Gardens, Yards and Shelterbelts.
Chemical Weed Control in Vegetable Crops and Small Fruits for Saskatchewan.
Farmstead Landscaping.
Seeding and Care of Lawns in Saskatchewan.

LIVESTOCK

Livestock production continues to be an important source of farm income in Saskatchewan. In recent years, sales of livestock and livestock products have brought Saskatchewan farmers about 239 million dollars annually, or 33 percent of the total farm cash income. Saskatchewan has approximately 2,100,000 beef cattle and 105,000 dairy cattle, 1,130,000 pigs, and 93,000 sheep. The livestock population should be expanded to meet market requirements and to provide a diversified agricultural industry for Saskatchewan.

BEEF CATTLE

Beef cattle provide a means of marketing pasturage, roughage, and feed grains. They can profitably utilize lower quality roughages and pasturage although they will respond favorably to higher quality feeds. The method of beef cattle production depends upon the amount and kind of feed available. Selling the calves at weaning (cow-calf operation) is the commonest method; however, where winter feed is relatively cheap and ample summer grazing is available, the calves may be overwintered and marketed as yearlings (cow-yearling operation). To utilize winter labor or local feed grains, a finish feeding program is often added to a farm or ranch operation. Profitable returns from any beef-cattle enterprise depend on the application of superior management techniques, as well as flexibility in response to market and feed-supply conditions.

Selection of Beef Cattle

Selection should be based on a combination of: 1. Efficient performance; and 2. a marketable product.

Performance characteristics are, in order of importance: 1. Reproductive ability; 2. rate of gain and weight for age; 3. milking and mothering ability; 4. hardiness; 5. longevity; and 6. temperament.

Although the market accepts all types of beef cattle, the preferred carcasses come from young (less than 2½ years old) steers and heifers, showing evidence of beef breeding (thick, even fleshing), in the live-weight range 950 to 1,150 pounds, and carrying a moderate amount of fat.

Reproductive Ability

The increased cost of beef production without a corresponding increase in the selling price for beef cattle has made it uneconomic to overwinter cows not carrying calves or to hold heifers over till 2 years of age for breeding. The explanation is that production costs are approximately $80 per cow per year and profits are approximately $20 per cow per year. A cow or heifer failing to wean a calf one year will have to calve regularly for the following 4 years to make up for the loss. Rectal palpitation by an experienced person identifies the cows or heifers not carrying calves so they may be culled. They eventually miss a breeding season completely and their late calves are usually not heavy enough at weaning time to cover the overhead charges.

Occasionally calves are born with such inherited conditions as cleft palate, enlarged head, or misshapen spine or legs. This is sufficient reason to cull the bull in commercial herds and both the cow and bull in purebred herds.

To avoid unbred cows and late calves, the reproductive ability of bulls should be determined by a veterinarian at the time of purchase and again before each breeding season. Any bull having swellings or evidence of irritation of the scrotum or penis, or abnormally sized, shaped, or positioned testicles is of questionable value as a herd sire.

Rate of Gain and Weight for Age

The fastest growing animals are the most economical to feed and, therefore, weights taken at weaning and at 12 and 18 months of age should be used in selecting replacements.

The performance of beef herds is evaluated through the Federal-Provincial Beef Cattle Record of Performance Program. Detailed information and assistance on initiating a testing program may be obtained from the Production and Marketing Branch, Saskatchewan Department of Agriculture, Regina. This program involves: 1. A home test in which groups of weaned calves are fed for 168 days, with beginning and final weighing supervised by an appointed inspector. The results are evaluated and the herd owner is given the final information adjusted for the age of the dam and calculated to provide an index on each animal; 2. a sire progeny test conducted at the Saskatchewan ROP Beef Cattle Test Station located at the University of Saskatchewan, Saskatoon. Five bull calves from one sire are fed for 168 days with similar groups from other sires; 3. associated with the sire progeny test on bull calves is a feeding and carcass test on 10 steer calves from one sire. The result is a comparison among sires, under uniform conditions.

Crossbreeding in Beef Production

Crossbred cows offer production advantages to the commercial cattleman. Experimental evidence and practical experience have shown that crossbred cows have the following advantages over straightbred cows:

1. They settle earlier in the breeding season; 2. with proper management, they can routinely drop their first calves at 2 years of age; 3. their calves are more vigorous, they milk heavier, and they wean a larger crop of heavier calves; 4. they are hardier, live longer, and are more disease resistant.

The selection of cattle to be used in crossbreeding must be based on points of economic merit. Crossbreeding is not a cure for poor management. Crossbred heifers, because of their high potential for growth, reproductive performance, and milk production may place greater demands on nutrition and management than straightbred heifers.

Crossbreeding programs may be divided into three categories:

1. A two-breed cross—all crossbred calves are sold.
2. A two-breed criss-cross—bulls of two breeds are alternated each generation using the crossbred heifers for replacements.
3. A three-or-more breed cross—a new breed of bull is introduced each generation to breed the last crop of crossbred replacement heifers. The management problems of maintaining several breeding groups can be solved by using artificial insemination or by different producers carrying out each step and exchanging breeding stock.

The Feeding and Management of the Beef Herd

Beef cattle do not require elaborate housing. Dry, well-ventilated, open sheds are satisfactory protection, as are groves of trees or slotted fences. Special provision for sick animals and for winter calving is necessary. Beef cattle

should be bedded generously. A chute and head gate should be available. Castration with a knife or emasculator and dehorning with dehorning paste, electric dehorner, or gougers should be carried out within 2 weeks of birth to reduce the setback from shock or fly strike. Significantly greater gains can be obtained by leaving bull calves intact, although herd management and market acceptance must be considered.

During winter, steer calves should be fed to gain from 1 to 1½ pounds per day. Any greater restriction does not result in a greater profit from the combined winter and summer pasture periods. Overwintering steers and heifers make good use of straw as a roughage, provided supplementation is supplied in the form of 4 to 5 pounds of grain, plus 1 pound of a protein supplement, plus minerals and a vitamin A supplement.

The breeding of yearling heifers has become an economic necessity. This requires that they be fed to grow steadily so they will be mature enough to breed and calve in the regular season. Calving difficulties with heifers can be reduced by not increasing the feed allowance during the last 3 months before calving.

Rapid and economical live weight is secured from good, well-managed pasture. Cattle coming off pasture in well-fleshed condition will winter better than cattle in poor flesh. Most native and tame grasses lose much of their nutritive value as they mature or after a killing frost. The use of late-seeded cereal pastures or the feeding of grain at this time will prevent severe weight losses. Since heavy stands of cereals may suffer up to 50 percent loss of plant material from trampling, zero grazing is suggested for obtaining higher live-weight gains per acre. (See Replacing Hay with Grain, page 150.) Low- or medium-quality hays or straws, properly supplemented with grain or a protein supplement and vitamin A, should be used for winter-feeding the mature beef herd. High-quality grass, cereal, or grass-legume hays and silages are very satisfactory, but are most effective when given to younger cattle or as a supplement to the low-quality roughage.

Harvested forage crops retain maximum amounts of nutrients when careful attention is paid to early cutting, proper curing, and good storage. Weathered or mature roughages and straw lack vitamin A. Synthetic, stabilized vitamin A supplements may be used at the rate of about 20,000 International Units (IU) per head per day. They are available in several potencies for use in feed or drinking water. Injectable forms are also available but usually cost more. Dehydrated alfalfa meal (¼ to ½ pound daily per head) will also supply the necessary vitamin A. Commercial beef-cattle protein supplements usually contain vitamin A as well as protein and may be obtained in meal, pellet, and cube form. The choice of supplements depends first on the quality of the feed and second on the comparative costs.

TABLE I*

Expected Daily Gains and Feed Requirements of Feeder Lambs and Cattle

Class of Animal	Purchase weight lb	Market weight lb	Avg daily gain lb	Avg number of days on feed	Feed per 100 lb gain		Feed Required to finish 100 head	
					Barley lb	Hay lb	Barley bu	Hay tons
Lambs, light	55	95	0.50	80	390	527	325	10.5
heavy	75	105	0.70	45	405	610	255	9
Calves, steers	430	1,020	2.5	240	600	300	7,100	88
heifers	400	850	2.2	205	620	310	5,600	68
Yearlings, steers	700	1,075	2.7	140	715	240	5,300	44
heifers	670	900	2.5	95	740	250	3,200	29
Two-year-olds, steers	890	1,150	3.0	90	770	260	4,000	33
heifers	850	1,000	2.5	60	790	270	2,400	20

*Local feed and livestock prices will allow producers to calculate the possibility of a profit using these average values.

Wintering beef cows require about 4,000 pounds of roughage over a 7-month period.

Warming water to 40°F is recommended.

The energy requirement of cows nearly doubles following calving because of milking and the need to gain weight before breeding. If pastures are not supplying necessary nutrients, these should be provided from supplemental forage or grain. Managing the cow herd in this manner will result in better calving percentages and fewer late calves.

Feeding for Market

The method of starting calves or yearlings onto feedlot rations will depend on the feeds and feed-processing equipment available. Where it is impractical to cut and mix roughages with the grain, cattle may be self-fed long hay. Whole oats should be offered the second day in the feedlot at the rate of 2 pounds per head for calves and 4 pounds for yearlings. The amount of oats should be gradually increased and replaced by coarsely ground or rolled barley or wheat until the animals are cleaning up approximately 10 pounds per day for calves and 15 pounds per day for yearlings (takes about 2 weeks). It may be necessary to restrict the hay offered to assure consumption of the grain. Where feed-processing and mixing equipment are available, feed long hay the first day, followed the second day by a complete ration of 70 percent ground roughage and 30 percent coarsely rolled or ground grain, plus supplements, although most portable farm mix-mills can handle only 50 percent roughage. The proportion of grain should increase until it represents 80 percent of the ration, or whatever level is practical under the local price of grain and the roughage quality.

Increasing use is being made of commercial feeds and of custom-mixing services. As a result, the rations may be more complete nutritionally, mixed better, and possibly more palatable. The extent to which one should become involved with commercial feeds or services depends on several factors. These include quality of the home-grown feeds (particularly protein and vitamin A contents), feed-processing equipment available on the farm, the distance from the mill, and the costs of alternative methods of obtaining a well-balanced ration.

Protein supplements may be required, particularly when poor-quality roughage makes up one-half or more of the daily ration, by weight, and when low-protein grain is fed. Under these conditions yearlings and older cattle will need about one-half pound of a protein supplement per head daily and calves from one-half to one pound per head daily, depending on the amount of feed consumed. With medium- or low-quality roughages, additional vitamin A should be provided at the rate of 1,000 to 1,500 IU per 100 pounds of body weight daily.

The use of self-feeders will give faster gains with lower labor requirements, but the best feed conversion can be secured from controlled feeding by a skilled operator. Water, salt, and a mineral mixture should always be available. (See Table IX page 151.)

Hormone preparations which are recommended for use with steers or feedlot heifers may be implanted in the ear or mixed in the feed carefully following instructions for implantation dates and withdrawal periods. When used properly they will increase gains. Hormone implants will also improve gain of cattle on good pasture, but the greatest benefits are obtained in cattle on full feed. Hormone products are now available for increasing gains in feedlot heifers through the reduced incidence of heat. Breeding stock must not receive hormone preparations.

Self-feeding grain on pasture has been found to be a useful alternative to finishing cattle in the feedlot. Stocking rates adequate to consume the available pasturage in early summer can be maintained by introducing grain gradually until self-feeding is accomplished. Gains of 2 pounds per day on well-managed pasture will increase to 3 pounds per day when the steers are on a full feed of grain. These cattle may often grade Canada Good and Choice directly off grain and pastures.

A good windbreak provides most of the necessary shelter, although a roof is desirable to keep snow off the backs of the cattle. If slats or boards are used for a windbreak, spaces equal to 20 percent the width of the boards should be left for greatest protection. Besides this porous fence, a regular snow fence should be provided to protect the feedlot. Ample bedding will increase feed efficiency.

Considerable interest is being shown in confinement housing of feeder cattle, a system that allows about 20 square feet per animal in well-ventilated sheds. The capital outlay is large and the economic advantage is still in doubt.

Marketing Beef Cattle

Today's consumers are in a position to insist on top quality. Most chain stores handle only beef from Canada Choice—Red Brand and Canada Good—Blue Brand carcasses. The high cost of fattening beef cattle requires that cattle feeders market their cattle with the minimum fat required for the Canada Choice grade.

Saskatchewan has a large potential for marketing finished cattle, and the cycles of weather and markets emphasize regularly the desirability of a year-round cattle-feeding industry in this province.

The strong demand (local, eastern, and export markets) for stocker calves and feeder steers provides the producer with an option of selling feeder cattle or finishing them to utilize local forages and grains.

Artificial Breeding

The extensive use of artificial insemination is a recent development in cattle breeding in the province. In 1970, through the use of frozen semen in community pastures, co-operative units, private breeding clubs, and individual herds, 2.0 percent of the dairy cows and 2.5 percent of the beef cows were artificially bred in Saskatchewan.

The greatest impact has been through dairy-cattle improvement, but the practice has been gaining popularity with beef-cattle breeders as well. The use of artificial insemination: 1. Provides the services of proven superior sires; 2. eliminates the inconvenience and cost of maintaining herd sires; 3. assists in controlling reproductive diseases; and 4. assists in carrying out a cross-breeding program.

DAIRY CATTLE

Operating a dairy herd as a major enterprise requires high capital investment, specialized knowledge, and managerial ability. Income is derived primarily from the sale of milk or cream, and is supplemented by the sale of market and replacement stock. Profits are greatly influenced by the quality of cattle, type of housing, regularity of breeding, success in raising replacement heifers, incidence of disease (especially mastitis), and the feeding program.

Housing and Equipment

The dairy cow requires an insulated, ventilated barn for maximum and efficient milk production. While most dairy herds have been housed in stanchion barns, an increasing number is being handled in comfort-stall and free-stall barns. As the trend continues to fewer and larger herds, greater attention will be given to barn layout and equipment to improve labor efficiency and cow productivity. Environment control (light, humidity, and temperature), automated feeding and manure disposal, parlor milking and pipeline systems, and bulk tank on-farm holding units must be considered when designing new barns or renovating older structures.

Selection

Milk production records are the main yardstick for selecting dairy cattle. The average annual production per cow of tested Holstein-Friesians in Canada is about 11,900 pounds of 3.7 percent butterfat milk. Top herds in Saskatchewan exceed the average by 50 percent. Replacement heifers from superior cows and sired by proven bulls should be kept and bred to proven bulls.

Certain aspects of type and conformation are important in selecting commercial dairy cattle. These aspects are limited to the functional ability of the dairy cow as a milk-and-calf-producing unit. Natural angularity and leanness, as opposed to a tendency for fattening, is associated with the ability to produce milk efficiently. Feet and legs under stanchion-type management need to be free from obvious weaknesses, such as shallow hooves and weak pasterns. Breakdown of the ligaments which support the udder and weakening of the sphincters which control the flow of milk from the teats contribute to bruised and diseased udders. Careful selection of breeding stock which do not display these weaknesses, combined with good milking practices, will reduce the serious causes of economic loss. (See Dairy Products section, Guide to Better Milking and Milking Equipment, page 97.)

Dairy Herd Improvement Services

Under the Dairy Herd Improvement Association program, a fieldman employed by the Saskatchewan Department of Agriculture visits members once a month to weigh, test, and record the milk and butterfat production of each cow in the herd over a 24-hour period.

In some Associations, the herds may be tested on a supervised route plan, under which the herd owners take their own samples and weights of milk. The fieldman leaves sample bottles, a scale, and a dipper at two or more farms, and the following day collects the samples and equipment. The samples are then tested at a central location and the production records entered in the herd books.

There is also a cow-testing plan in which the herd owners weigh and sample the milk from each cow 2 days a month and then forward samples to an official testing centre.

Record of performance (ROP) is a service provided by the Canada Department of Agriculture for recording milk and butterfat production of dairy cattle.

Herd Replacements

Where a proven sire is in use, heifers should be raised from the superior cows, since cows and heifers of desirable quality are difficult to buy, and increase the possibility of introducing disease into the herd. Where artificial insemination is available, the opportunity for raising the replacement heifers from superior sires is greatly increased. The poorer third of the cows may be bred to beef bulls artificially.

Feeding for Production

Production is the major economic factor in a profitable dairy enterprise. A cow that gives 3,000 pounds of milk annually uses only one-quarter of her feed intake for milk production, whereas a cow that gives 8,000 to 10,000 pounds converts more than one-half of her feed into milk. In the second example, the feeding cost of producing milk is cut nearly in half.

Milk production tends to drop as pasture quality decreases in June and July. Hot weather and flies are often blamed but the decline is mostly the result of underfeeding. It can be offset by providing silage or good-quality hay at all times, even when the pasture is very lush in the spring. Supplementary cereal pasture has also proven satisfactory. (See Forage Crops section, page 55.)

By feeding grass silage along with a good-quality dry roughage, farmers can provide a balanced ration using their own coarse grains without supplementary protein.

A dairy meal containing cereal grains plus a protein supplement, minerals, salt, and vitamin A should be fed

according to the level of milk production, percent butterfat in the milk, size of cow, and roughage quality, as indicated in Tables II, III, and VII.

The kind and quality of roughage determine the kind of concentrates necessary. Alfalfa and clover hays go very well with a mixture of cereal grains. Prairie hay, tame grass, or cereal hay may require that some protein supplement be mixed with the cereal grain. A mixture of ground or rolled grains of medium weight (about 40 pounds per bushel), along with a 32 percent protein supplement, will be suitable. Succulence is not essential to the dairy ration, but cows relish green grass, good silage, dried beet pulp, and molasses. These products will most economically be used in only small amounts to stimulate appetite, unless their prices correspond closely to those of farm grains used for feed.

TABLE II

Dairy Meal Feeding Guide

For mature cows weighing 1,300 or 1,700 pounds and consuming 2% of body weight daily as hay equivalent.

Butterfat percentage	3%		3.5%		4%		4.5%	
Body weight (lb)	1,300	1,700	1,300	1,700	1,300	1,700	1,300	1,700
Daily Milk lb								
20	3	1	4	2	5	3	7	4
30	7	4	9	6	10	8	13	10
40	12	10	14	11	15	13	19	16
50	18	16	20	17	22	20	26	24
60	25	22	27	24	30	27	34	32
70	30	27	32	30	35	33	—	38
80	35	32	—	35	—	39	—	—
90	—	—	—	—	—	—	—	—

Where blanks occur, feed dairy meal to appetite or to ability of the cow to handle grain.

TABLE III

Dairy Meals for Replacement Calves, Bulls, Dry Cows, and Lactating Cows

	Ration			
	A	B	C	D
Barley	48 lb	45 lb	50 lb	40 lb
Oats	30 lb	20 lb	20 lb	13 lb
Wheat	20 lb	10 lb	20 lb	25 lb
Wheat Bran	—	10 lb	—	—
Rapeseed meal	—	5 lb	—	—
Soybean meal	—	7 lb	—	—
32% crude protein concentrate	—	—	10 lb	22 lb
Ground limestone	—	0.5 lb	—	—
Bone meal or dicalcium phosphate	1.0 lb	1.5 lb	—	—
Salt, cobaltized-iodized	1.0 lb	1.0 lb	—	—
Vitamin A, per lb of meal	3,000 IU	3,000 IU	2,000 IU	4,400 IU
Vitamin D, per lb of meal	200 IU	200 IU	400 IU	880 IU
Crude protein, %	13%	16%	14%	16%
Calcium, %	0.30%	0.70%	0.52%	0.92%
Phosphorus, %	0.48%	0.64%	0.40%	0.63%
TDN	72%	71%	72%	70%

A. For use only with excellent-quality roughage, at least 50 percent of which is legume. Many combinations of cereal grains can be used. In general, wheat or oats should not make up more than 40 percent of the ration and barley not more than 60 percent.
B. For use with medium-quality grass hays and silages.
C. For use with very good quality grass-legume forage.
D. For use with lower quality forage.

Many nutritional diseases are due to mineral deficiencies in the ration. (See Table IX.)

Grain for dairy cows should be coarsely ground or rolled. Grinding roughage is not necessary.

Care at Calving Time

Dairy cows require a dry period of 6 to 8 weeks to restore body reserves for lactation. During the last month of milking and in the dry period, feed should be sufficient to ensure a strong, thrifty condition at calving time. If lush pasture or silage is not available, high-producing cows should be fed concentrate for 2 to 3 weeks before calving. By calving time each should be receiving 8 to 15 pounds of concentrate daily. For 2 to 3 days prior to calving, part of the concentrate can be replaced with bran. After calving, increase the concentrate rapidly to maximum appetite or maximum milk yield, whichever is reached first. In winter, cows should be placed in clean, comfortable pens with plenty of dry bedding 2 or 3 days before calving.

An attendant should be nearby to give assistance at calving time. Sometimes a membrane will be found clinging to a calf's nostril; this should be removed quickly to allow free breathing. The navel cord should be dipped in a tincture of iodine to prevent infection. If a cow refuses to lick her calf, the attendant should rub the newborn vigorously with a dry sack. After calving, avoid milking cows dry for 2 or 3 days, or until danger of milk fever is past.

Feeding Calves

The first milk, or colostrum, is necessary for the health and thriftiness of newborn calves. Colostrum is high in protein and mineral matter and rich in vitamin A, and it contains immunity factors necessary for disease resistance during the first few weeks of life. Vitamin A deficiency may lead to scours, colds, eye trouble, pneumonia, general unthriftiness, and even death.

Following 2 or 3 days of colostrum feeding there are several alternatives: 1. Feeding a milk replacer until the calf weighs 150 pounds or is 6 weeks of age. This method has proven practical and most economical where fresh milk can be sold; 2. feeding skim milk fortified with water-dispersible vitamins A and D (1,000 and 100 IU daily) along with starter; 3. feeding whole milk for 2 or 3 weeks, followed by skim milk or milk replacer, along with calf starter.

From 6 to 10 pounds of mother's milk a day is a suitable allowance for the first 2 or 3 days. After that, a daily ration of milk equal to 10 percent of the calf's weight is a reliable rule.

If skim milk is in short supply, a good calf meal will be required until the calves are 3 to 4 months of age. Commercial calf meals will give good results if used according to recommendations. Although only small amounts are needed, quality is important.

If skim milk is available (up to a maximum of 15 to 20 pounds per day) until 6 to 7 months, complicated calf meals will not be necessary. Besides skim milk, a mixture of oats (of good quality), bran, and an oilseed meal should be fed in the proportions of 70 pounds oats, 15 pounds bran, and 15 pounds of oilseed meal. Good-quality roughage, preferably legume, should also be fed. The feeding of grain mixtures and hay should begin as early as calves will eat them. Fresh water and a mineral mixture should be available at all times.

Scours in young calves indicate digestive troubles. Overfeeding is the most common cause, but sour milk and dirty feed pails may also be responsible. When scouring occurs, the amount of milk fed should be reduced to half or less and the volume made up with water. Only fresh milk and scrupulously clean utensils should be used. Infectious scours can be a much more serious problem. (For information on this condition, see Animal Diseases section, page 154.)

Calves should be housed in a dry, well-ventilated building. Rearing in individual pens (4 by 6 feet) will facilitate accurate observation, disease control, and prevention of sucking, which is a habit often acquired under group rearing.

Dairy-Beef Production

In Saskatchewan, the market value of the milk required for veal production usually exceeds the market value of the veal calf produced. These excess calves are more profitable if raised similar to herd replacements until they weigh 250 pounds, and then: 1. They weigh 950 to 1,000 pounds or have sufficient finish to grade Canada Standard; 2. or are pastured with creep feed available during the summer and then fed an all-grain ration until they will grade Canada Standard.

Milk Replacers

Dairy and orphan beef calves must often be raised where whole or skim milk is not available. In such cases commercial calf milk replacers or substitutes may be worthwhile. These contain dried milk byproducts and various low-

fibre feedstuffs, together with supplementary minerals, vitamins, and antibiotics. The mixture of about 1 part powder to 8 parts warm water is fed at the same rate as milk, gradually increasing to 18 pounds (1⅘ gallon) per day. Provided the purchase price per pound does not exceed the farm value of about 2 quarts of milk, the use of replacers should prove economical for fluid-milk shippers. After becoming accustomed to a good calf meal, good-quality hay, and fresh water, calves may be "weaned" gradually when about 6 weeks of age. The drinking water may have to be removed for a while after feeding milk to prevent the consumption of too much liquid at one time. For early weaning, the feeding of a good-quality commercial calf meal may be advisable until 3 or 4 months of age, when a simpler mixture will be adequate. (See Feeding Calves, page 144.)

Breeding Weights

Because of variations due to feeding, management, and breed, weight rather than age should be used as a guide to ensure adequate development for the first calving. The recommended breeding weights are:

Jerseys	550 pounds
Guernseys	600 pounds
Ayrshires	650 pounds
Holsteins	750 pounds

These weights should be attained between 15 and 18 months of age.

Herd Sires

Exercise is essential to the health, thrift, and breeding ability of the herd sire. The sire's feet should be trimmed at least twice a year. The hoof should be trimmed from the underside to form a level bearing surface. When the outer edge is cracked or badly formed, trim the edge with pincers and a coarse rasp.

Good-quality roughage, supplemented with dairy concentrate, should be fed in amounts sufficient to keep the sire in medium flesh. Water and access to salt and minerals should be provided. Proper care, management, housing, and feeding are necessary for satisfactory breeding results.

Remember, the bull is one of the most dangerous animals in North America. Handle with caution and provide every possible safety measure. Consider artificial insemination as an alternative to maintaining your own herd sire.

HORSES

The light horse is still important on many livestock farms and is becoming economically important for the livestock industry because of the growing demand for pleasure horses.

Horses at hard, medium, or light work will require, respectively, about 2, 1¾, and 1½ pounds of dry feed daily for each 100 pounds of live weight. This should be made up of about 3 parts roughage to 2 parts grain. (The proportion of grain should depend on the condition of the horse and the level of work.) Horses removed from heavy work should have their grain portion dropped sharply to avoid digestive complications. Although oats are generally the preferred grain, barley and wheat can be used, recognizing that less will be required. Avoid feeding dusty hay to horses; it often leads to respiratory difficulties. Iodized salt and a mineral mixture should be available at all times. Unless the forage is of high quality, vitamin A supplements should be provided as well.

Care of the Brood Mare and Foal

The in-foal mare needs little special feed or care until near foaling time, but should have daily exercise. Mares that foal before the pasture season should receive a grain ration to ensure thriftiness, and a good milk supply. A mixture of oats and bran is very satisfactory. The oats should be decreased and the bran increased about a week before foaling. Roughages of good quality should be fed. Mares with foals will require 2.2 pounds of dry feed daily per 100 pounds of body weight. One tablespoon of potassium iodide solution (see Mineral Supplements, page 150) should be provided daily for at least the last 3 to 4 months of pregnancy to prevent weak foals with increased susceptibility to navel infections and joint-ills.

The orphan foal should receive one-quarter pint of warmed, low-butterfat cow's milk each hour from a nursing bottle to which has been added 1 teaspoonful of sugar and 4 tablespoonfuls of limewater (saturated solution of unslaked lime in water). Decrease the frequency and increase the amount until the foal can be fed from a pail. (See Milk Replacers, page 146.)

SHEEP

Sheep raising in Saskatchewan is changing, with the number of large range flocks declining, and the number of farm flocks with a trend to confinement-rearing showing a modest increase.

Sheep make good use of improved pastures as well as native pastures on nonarable lands. When sound management practices are followed, sheep provide a good return on investment.

Partial or total confinement of sheep to a drylot, combined with early weaning (40 pounds), feeding lambs on slotted floors for early marketing, dropping ewes to maintenance level rations after weaning, and out-of-season lambing are the new alternatives to the traditional sheep-production pattern. Reduced fencing cost, internal parasites, and predator problems, plus more rapid lamb gains are advantages.

Facilities

Sheep suffer more from draughts and moisture than from low temperatures. A shed of straw or frame construction, approximately 30 feet deep, open to the south and with a rainproof roof, is sufficient. Mature sheep need from 12 to 16 square feet of floor space per head, apart from space for feed racks. For early lambing, a more elaborate closed-in building will be required. With small flocks, an area of the stable or similar building can be used during this period.

Adequate fencing is a major requirement. Woven wire is preferred.

Breeding Stock

Factors to consider in selecting breeding stock are: 1. Fertility — which, for farm flocks emphasizes the tendency for twinning and breeding out of season; 2. growth rate — a lamb that will grow at 0.5 pounds per day or better and finish at from 95 to 105 pounds; 3. wool production.

One source of breeding stock for farm flocks is the surplus from range bands. These hardy, long-lived sheep give heavy fleeces of high quality. They flock well and are capable of raising good lambs on relatively poor pasture. Young ewes are usually the best buy. Whatever the age of the ewes bought, they should be uniform in size, fleece type, conformation and breeding, and they must be sound in mouth and udder. For range production they should be mated to rams of recognized range breeds. Under farm conditions, they should be mated to rams of the "down" breeds to produce good market lambs.

Crossbreeding has been shown to impart hybrid vigor to the offspring, resulting in more rapid and efficient growth. Where replacement females can be bought at reasonable prices, it is generally more profitable to sell all crossbred offspring and use the same ram as long as he is breeding well. However, as crossbred females are usually more prolific and better milkers than their straightbred counterparts, crossbred ewe lambs could be grown out and bred to a ram of a third breed. All lambs from this cross should be marketed.

Management

For about 1 month before breeding, the dry ewe should be given extra feed of high quality. This practice is called "flushing" and tends to increase the number of multiple births. Flushing can be accomplished on good pasture or by feeding 1 pound of grain per ewe daily. The ram should receive 1 to 2 pounds of grain daily for 1 month before and during the breeding season.

In a farm flock, a yearling or mature ram will breed 40 to 50 ewes per season, while a growthy ram lamb of the larger breeds can serve about 20. In large range flocks the general practice is to use three mature rams per 100 ewes. To be sure that a ram is breeding satisfactorily, coloring material placed on its chest or a marking harness can be used. Changing the color at 17-day intervals will show which ewes are being rebred. If many ewes are returning, a new ram must be obtained immediately. The gestation period is approximately 145 days; daily exercise is essential for the ewes throughout this period.

In winter, good-quality legume hay should make up one-third to one-half of the roughage fed to the ewe flock. Low-quality roughage such as poor hay or cereal straw may have to be supplemented with grain and a protein supplement, with 3,000 IU of vitamin A per ewe daily.

Beginning about 1 month before lambing, one-half to one pound of farm grain should be fed to each ewe daily to ensure strong lambs and a good milk flow. It is advisable at this time to vaccinate the ewes with Perfringens Type D vaccine to prevent losses in the young lambs from over-eating disease. Before lambing, the wool around the udder and lower rump should be trimmed off; otherwise, the young lambs may swallow wool tags.

In mild weather, the best place to lamb is on a clean paddock or pasture. In bad weather, adequate shelter and the use of heat lamps will help to prevent losses. As a precaution against disease, dip the navel cord of the new-born lamb in a tincture of iodine solution. Some lambs may need help to obtain their first feed. The ewe and lambs should be confined to a 4- by 4-foot "claiming pen" for 1 to 3 days or until the lambs are nursing satisfactorily. Creep feeding with whole oats results in faster growth and better finish at weaning.

All the lambs should be docked and vaccinated for enterotoxemia (see page 160) and the male lambs castrated by 2 weeks of age. Water, cobalt-iodized salt, and a mineral mixture should be available to ewes and lambs at all times.

Milk Replacers for Lambs

Ewe's milk is slightly richer in protein, fat, and minerals than cow's milk. For a replacer, add 1 to 2 teaspoonfuls of milk powder per pint of cow's milk and bottle-feed at body temperature, 1 to 2 ounces per feeding every 2 hours. A high-fat commercial milk substitute would perform satisfactorily. Gradually reduce the number of daily feedings and provide free access to creep feed and water.

Feeding Lambs

Where possible, lambs should have free access to a creep feed or starter ration from 2 weeks of age. Starter rations should be high-energy, high-protein mixtures with added vitamins A and D, minerals (calcium and phosphorus), and cobalt-iodized salt, and be very palatable if the lambs are to gain up to three-quarters of a pound per day.

Unless pastures are particularly good, lambs should be weaned at 60 pounds (or less) and placed in a feedlot. Market lambs will eat up to 3½ pounds of feed per day and gain from 0.6 to 0.8 pounds per day if hay is limited to one-half of a pound per day and a grain ration is fed up to the limit of appetite. To avoid digestive disturbances, start lambs on feed gradually and vaccinate for enterotoxemia.

Ram lambs will gain more rapidly and efficiently than wethers or ewe lambs, and are not discriminated against in the market until about 6 months of age. However, ram lambs must be penned separately or breeding activity will occur after 2 months of age.

Slaughter lambs should be finished between 80 and 110 pounds (36 to 56 pounds carcass weight). Some reach this condition by 3 to 4 months, particularly if creep fed. Great variation exists in the market price paid for lambs among market centres because of the variable supply, so careful consideration should be given to market quotations from several centres. Spring and early-summer markets usually provide attractive premiums justifying the special breeding and feeding required to supply them.

Shearing

Sheep should be shorn during the first half of June. Care must be taken to keep the wool clean and in good condition to ensure the top market price. Where groups request them, shearing and management schools will be organized by the agricultural representative.

The following points are important: 1. Shear ewes before turning them on summer pasture; 2. shear sheep when they are dry; 3. shear on a clean floor; 4. keep the fleece in one piece and avoid second cuts; 5. keep the wool free from dirt or vegetable matter; 6. spread the fleece, flesh-side down, on a slatted table about 4 by 8 feet and about 3 feet high; 7. remove all tags, leg and face clippings, burry or chaffy pieces (pack these separately); 8. fold the fleece in from the sides, one side overlapping the other, roll tightly from breech to shoulder, and tie with a paper string; 9. pack tightly in proper wool sacks. Paper strings and wool sacks are obtainable from wool-handling companies.

Predators

Losses from coyotes and dogs have compelled many farmers to give up sheep raising. Where the coyote-control program has been carried out by the provincial government and rural municipalities, the coyote menace is much reduced. Sheep breeders are protected to some extent from losses by dogs by the Sheep Protection and Dog Licensing Act.

Additional Information

Bulletins, building plans for housing and equipment, etc., are available from the Extension Division, University of Saskatchewan, Saskatoon; agricultural representatives; C.D.A. research stations and farms; and Information Canada, Ottawa.

Information on the Saskatchewan Graded Ram Purchase Policy and the Federal-Provincial Freight Assistance Policy for breeding ewes is available from agricultural representatives and the Production and Marketing Branch, Saskatchewan Department of Agriculture, Regina.

For sources of breeding stock, write Saskatchewan Sheep Breeders' Association, Exhibition Grounds, Regina; Southern Saskatchewan Wool Growers' Association, Maple Creek; Federal Livestock Division, 841 Motherwell Building, Regina; or Production and Marketing Branch, Saskatchewan Department of Agriculture, Regina.

See also the sections on Insect Pests and Animal Diseases and the Mineral Supplements part of this section.

SWINE

Producers who raise hogs year after year and make slight adjustments in volume to offset expected gluts or scarcities usually succeed in the hog business. A permanent program of pig production should be related to feed and water supplies. (See Additional Information, page 149 and Swine Production, Canada Department of Agriculture.)

Housing

Much of the success in hog raising depends on well-planned housing. A suitable environment is extremely important for the survival of baby pigs; any appreciable

departure from the ideal housing temperature of 50° to 70°F results in increased production costs for market hogs. Brood sows are often kept in inexpensive moveable colony houses or baled straw shelters, amply bedded and protected to provide warm sleeping quarters. Ventilation must be provided to avoid high humidity in winter housing.

For economical, year-round production, permanent housing is essential. Many new developments pertaining to manure and feed handling and confinement housing of sows have occurred recently. Advice should be sought to ensure a wise choice of mechanizing and automating equipment and building design; otherwise, capital outlay may become too high for profitable operation.

Floor-area requirements range from 3 square feet for weanlings to from 8 to 10 square feet for 200-pound pigs; dry sows require 20-35 square feet, and sows with litters require from 35-80 square feet, depending upon the type of facilities used.

Plans for housing may be obtained. (See Additional Information, page 149.)

Selection of Breeding Stock

Breeding stock should be selected from top-performing strains or families. Selected boars should equal or excel the performance of the better performing sows in the herd. Breeding gilts should have 12 normal teats and come from prolific, rapid-growing strains which produce high-yielding carcasses. Sows and boars from litters in which intersex, cryptorchid (ridgling), or ruptured pigs have occurred should not be kept for breeding. Special attention should be given to diseases, and disease control may be important enough for some breeders that they may consider sources of SPF (Specific Pathogen-Free) pigs when purchasing a new herd (See C.D.A. Publ. 1442—Section 5 on Swine.)

A new ROP (Record of Performance) policy has been introduced based on research findings which show that the amount of backfat measured at three locations in the live hog is a good indication of the yield of lean meat. The new program has two parts:

1. Boar Performance Home Test—a backfat and weight-for-age program for all boars when weighing between 180 and 220 pounds.

2. Sire Progeny Test (Saskatoon Test Station)—groups of eight pigs from the same sire, comprising two pigs of either sex from each of four litters and from sows (preferably gilts) of similar breeding, are feed-tested during an established contemporary period.

It is recommended that breeders make use of the first or both phases of this program. In addition, herd improvement is very dependent on selecting gilts with better than average backfat probe values and maturity indexes.

The ROP program provides for testing purebred animals and nonpurebreds of identifiable parentage.

Crossbreeding

A well-planned crossbreeding program, involving high-quality individuals of two or more breeds or strains, offers marked advantage to the commercial producer. Larger, more vigorous litters and faster growth rates are typical results of crossbreeding. Crossbred females make excellent brood sows. The success of a crossbreeding program depends on adherence to a planned mating system.

Feeding

Swine grow rapidly and reproduce early, so nutritional deficiencies can develop, with serious economic losses, if balanced rations are not provided. A crude protein analysis is recommended as a basis for determining the kinds and amounts of supplements needed in swine rations. (See Feed Testing Services, page 152.)

Feed grains are deficient in crude protein (and the essential amino acids lysine and methionine), calcium, phosphorus, vitamins A and D, and may be deficient in certain trace minerals and B-complex vitamins as well. It is necessary, therefore, that a protein-mineral-vitamin supplement be provided. It can be formulated by the producer, but it is generally recommended that a commercial supplement ("hog concentrate" or "sow concentrate") be used.

Some producers, particularly large-scale producers, prefer to use "complete" or "formula" feeds. It is recommended such feeds be used for the starting period, in view of their complex nature. For growing-finishing pigs and sows, the choice between complete and home-mixed rations must be made on economic grounds. Producers are advised to seek professional advice before making this decision.

Suggested rations for sows, and growing-finishing pigs are given in Tables IV, V and VI.

Care of the Brood Sow

The feeding program during pregnancy is extremely important for the production of strong pigs and a good milk supply. Grains fed to pregnant sows must be supplemented with extra protein, minerals, and vitamins to prevent nutritional deficiencies. Suggested formulae are listed in Table IV.

Seeded pasture, in season, provides part of the extra vitamins, minerals, and protein needed by pregnant or dry sows, so that the amount of supplement may be reduced. Only young, lush forage can be utilized by sows and this must be supplemented with gestation rations, not grain alone.

TABLE IV
Sow Rations
(Gestation and Lactation)

	A	B	C
Wheat, ground	75.0 lb	65.0 lb	10.0 lb
Barley or heavy oats, ground	—	10.0 lb	75.0 lb
Light oats, ground	10.0 lb	10.0 lb	—
Alfalfa meal	5.0 lb	5.0 lb	5.0 lb
38% "sow concentrate"	—	10.0 lb	10.0 lb
Soybean or linseed oil meal	4.5 lb	—	—
Meat meal	2.0 lb	—	—
Fish meal	2.0 lb	—	—
Salt (iodized)	0.5 lb	—	—
Ground limestone	0.5 lb	—	—
Bone meal	1.5 lb	—	—
Zinc oxide	0.01 lb	—	—
Vitamin A	250,000 IU	—	—
Vitamin D_2	20,000 IU	—	—
Vitamin B_{12}	1,000 mcg	—	—
Crude protein (min) %	15	15	15
Estimated total digestible nutrients (TDN) %	75	75	75

Gilts and sows should be restricted to 4.5-5.5 lb of gestation ration per head daily. These allowances may need to be increased for very thin animals or in very cold weather. Gestation rations must be diluted, preferably with additional alfalfa meal, if they are to be self-fed.
Lactation rations may be self-fed. Consumption will range from 12-20 lb per sow daily. Maximum consumption should be encouraged during lactation.
This level may not be adequate if grain is low in protein.
The gestation-lactation ration is an excellent feed for the breeding boar.

TABLE V
Growing Rations

	A*	B*	C*
Wheat, ground	40.0 lb	28.0 lb	47.0 lb
Barley, ground	25.0 lb	56.0 lb	—
Heavy oats, ground	19.5 lb	—	37.0 lb
38% "hog concentrate"	—	16†	16†
Soybean, linseed, or rapeseed oil meal	8.0 lb	—	—
Meat meal	2.0 lb	—	—
Fish meal	2.0 lb	—	—
Alfalfa meal (dehydrated)	2.0 lb	—	—
Salt (iodized)	0.5 lb	—	—
Ground limestone	0.5 lb	—	—
Bone meal	1.0 lb	—	—
Zinc oxide	0.01 lb	—	—
Vitamin A	90,000 IU	—	—
Vitamin D_2	15,000 IU	—	—
Vitamin B_{12}	600 mcg	—	—
Antibiotic**(broad spectrum)	1.0-2.0 gm	—	—
Crude protein (min)%	16	16	16
Estimated TDN %	75	75	75

*It is advisable when barley is available at an appreciably lower price per pound than wheat, to utilize this grain more extensively in grower rations, high-energy finisher rations and sow rations, even though the resulting TDN level may be slightly below requirements.
**1.0 gm adequate under most conditions.
†This level may not be adequate if grain is low in protein.
Grower rations should be self-fed from 50-110 lb.
Consumption will range from 150-200 lb per pig.

Farrowing and Nursing

Special attention at farrowing time promotes survival of the young pigs. The farrowing pen should be clean and equipped with a guardrail to prevent crushing of the baby pigs by the sow. For bedding, short straw used sparingly will avoid restricting the movement of the small pigs. If their temporary tusks interfere with nursing, they should be removed with small, sharp, side-cutting tooth nippers.

A brooder can be easily and cheaply built by nailing a strong, 3-foot-high, 6-foot-long partition of three 2- by 8-inch boards across the corner of the pen. An 8-inch space is left at the floor and fitted with a top-hinged door. A 250-watt heat lamp covered with a screen (as a fire precaution) is suspended over the brooder area at least 18 inches from the floor or bedding. A 150-watt bulb may be substituted as the heat requirements of the pigs decline. The heat at the floor can be adjusted by changing the height of the lamp. Pigs that are comfortable do not pile up. Three weeks is generally long enough to use the lamp but in very cold weather an extra week may be desirable. A brooder is also useful for a creep, since the sow is prevented from entering the corner.

Farrowing crates, stalls, and floor heating are recommended to provide safe accommodation for young litters. Plans for farrowing crates are available. (See Additional Information, page 149.)

A sow may be encouraged to adopt strange pigs if its own and the newcomers are given a mild creolin odor, or if the strange pigs are rubbed with the sow's own to acquire a familiar odor.

Constipation often troubles sows about farrowing time. Wet feeding is advisable, along with the inclusion of 5 to 7 percent dried beet pulp or about 25 percent wheat bran in the ration. After farrowing, several days should elapse before the sow is brought to full feed, but generous feeding is important from then on if the sow is to nurse a large litter. For nursing sows, feed a grain ration of predominantly ground barley or ground wheat along with 12 or 15 percent of a protein-mineral-vitamin supplement (sow concentrate).

To prevent anemia, pigs raised indoors should be treated with an iron preparation. Injectable iron dextran is preferred. As an alternative, an oral preparation may be given at 2, 9, 16, and 23 days of age.

Suckling pigs should be encouraged to eat solid feed as soon as possible to supplement the sow's milk, reduce the drain on the sow, encourage even development, and minimize the intestinal disturbances which often occur at or shortly after weaning. A commercial creep feed should be made available at 10 days of age. Where pigs are being weaned at 5 weeks of age or earlier, the creep feed should be a high-protein prestarter or early-weaning ration. An 18-percent-protein starter is satisfactory for pigs weaned at 6 weeks of age or later. Ready access to fresh water is extremely important in encouraging creep feed consumption. Care should be taken to keep utensils clean and the feed fresh.

Weaning

Pigs are usually weaned at 4 to 6 weeks of age. Although this requires an early weaning ration, it allows earlier rebreeding of the sow and results in more uniform pigs. If swine are only a minor sideline or if scouring is a serious problem, weaning at 6 to 8 weeks is often preferred. Male pigs not intended for breeding should be castrated about a week before weaning.

It is vital for protection against disease that pigs receive colostrum (first milk) during the first day of life. Afterwards, a milk substitute can be fed when a sow has insufficient milk for the litter. Sow's milk is rich in protein and fat. A tablespoonful of milk powder added per pint of cow's milk will produce a satisfactory substitute. This should be fed warm five or six times daily, a few ounces at a time. Pigs will soon learn to use a pan or a fountain as well as a bottle. Commercial pig-milk replacers, based essentially on milk byproducts and well fortified with vitamins, minerals, and antibiotics, are recommended where a number of pigs are raised artificially. Frequent, thorough cleaning of troughs, waterers, etc., is extremely important. Regardless of the milk substitute used, the pigs should be "weaned" onto a good starter and water at an early age, at least by 6 to 8 weeks.

Growing and Finishing for Market

Healthy, well-managed pigs require from 3 to 4 pounds of feed for each pound of weight gained between weaning and marketing. Diseases, poor housing, or poorly balanced rations will greatly increase feed requirements and reduce profits.

Following weaning, pigs require a low-fibre, high-protein ration until they weigh 125 pounds. Extensive use of high-energy grains (wheat, barley, or heavy oats) during the finishing period may lead to overfat carcasses and downgrading. (See Table VI.) The long-range objective should be the selection of breeding stock that yield lean carcasses, along with high rates of gain. Contrary to common opinion, heavy, fat hogs are not more profitable than lean hogs. Under the new grading system, lean carcasses will earn the premium values, while overfinished carcasses will be penalized. Marketing pigs alive between 180 and 210 pounds should yield carcasses within the preferred weight range. Gilts characteristically yield better carcasses than barrows. Separation of the sexes to permit restricted feeding of barrows will improve average grades. Dilution of the finishing ration with a considerable quantity of oats or 10 to 20 percent ground roughage will provide a low-energy ration for self-feeding, but this is not always an economical way of obtaining leaner carcasses. Restricting the ration intake is usually the most economical approach to ensuring leaner carcasses.

The ration for growing pigs should include an antibiotic feed supplement. The amount of active antibiotic necessary will range from 10 to 50 grams per ton, depending upon the disease level.

A good-quality seeded pasture, if limited, should be reserved for brood sows. But, if available for feeder pigs, it will provide much of the required protein, vitamins, and minerals, and reduce grain consumption. However, gains on good pasture, while usually cheaper, are also generally somewhat lower; indoor production in good facilities is more profitable as a rule.

It is important that pigs receive plenty of good-quality water at all seasons. Several types of self-waterers are now available. They save labor and assure a continuous, fresh water supply.

Marketing

A weighing scale is an essential item of equipment for hog producers as is a backfat probe for selecting breeding stock.

Overfinish is the main cause of low returns and higher feed costs. The producer receives a rail grade settlement for every hog shipped, and should use the information provided to determine the causes of low returns and to identify superior strains. Quality of breeding stock, marketing weight, and makeup of the finishing ration must all be carefully considered if returns are to be improved.

Feeding Method

The self-feeder saves labor and can be used successfully for market pigs. Experiments show an increase in daily gain over hand feeding, although this is partly offset by the use of more feed per pound of gain. To reduce wastage, self-feeders should be carefully constructed and have a baffle or sliding panel that must be kept adjusted for the texture of the feed. Various automatic feeding systems are available and in use in modern swine barns. Some involve feeding

directly from the concrete floor. Others involve liquid feeding from troughs. Plans for self-feeders may be obtained. (See Additional Information on this page.)

Sanitation

Clean housing is essential for all swine-raising operations. Buildings and equipment should be cleaned and disinfected at regular and frequent intervals. A high-pressure water spray (500-600 psi) or a boiling-hot lye solution (1 ounce in 1 gallon water) should be used for cleaning.

TABLE VI

Finishing Rations

	A*	B*	C*	D**	E**	F**
Wheat, ground	60.0 lb	40.0 lb	15.0 lb	—	73.0 lb	—
Barley or heavy oats, ground	—	35.0 lb	75.0 lb	25.0 lb	—	80.0 lb
Light oats, ground	30.0 lb	15.0 lb	—	65.0 lb	—	—
Oat hulls or ground straw, fine	—	—	—	—	15.0 lb	8.0 lb
38% "hog concentrate"	—	10.0 lb †	10.0 lb †	—	12.0 lb †	12.0 lb †
Soybean, linseed, or rapeseed oil meal	5.0 lb	—	—	5.0 lb	—	—
Meat meal	1.3 lb	—	—	1.3 lb	—	—
Fish meal	1.3 lb	—	—	1.3 lb	—	—
Alfalfa meal (dehydrated)	1.3 lb	—	—	1.3 lb	—	—
Salt (iodized)	0.5 lb	—	—	0.5 lb	—	—
Ground limestone	0.3 lb	—	—	0.3 lb	—	—
Bone meal	1.0 lb	—	—	1.0 lb	—	—
Zinc oxide	0.01 lb	—	—	0.01 lb	—	—
Vitamin A	90,000 IU	—	—	90,000 IU	—	—
Vitamin D2	9,000 IU	—	—	9,000 IU	—	—
Vitamin B12	600 mcg	—	—	600 mcg	—	—
Crude protein (min)%	14	14	14	14	14	14
Estimated TDN%	75	75	75	70	70	70

*Rations A, B and C are high-energy finishers, and consumption should be restricted to 5 lb per head daily. Consumption will range from 275-325 lb per pig.
**Rations D, E and F are low-energy finishers, and may be self-fed. Consumption will range from 300-350 lb per pig. A TDN level of 67 percent is recommended for a self-fed barrow.
†This level may not be adequate if grain is low in protein.

Treatment for Round Worms

The main internal parasite affecting swine is the common round worm ascarid. (See C.D.A. Publ. 1442—Section 5 on Swine.)

Additional Information

Production and management bulletins, building plans, information on policies, etc., may be obtained from the Extension Division, University of Saskatchewan, Saskatoon; agricultural representatives; or research stations. Information on record of performance of swine is available from the Federal Livestock Division, 841 Motherwell Building, Regina.

FEEDING LIVESTOCK

Special Feeding Problems

Illness, unthriftiness, and mortality in livestock may be due in some cases to toxic materials in the feed or drinking water, or to other poisonous substances to which the animals have had access. The following include the most commonly occurring problems in Saskatchewan.

Ergot—Grain samples containing more than one ergot body per thousand kernels are considered toxic. Ergot causes abortion and may result in faulty circulation to the feet, tail, ears, etc., resulting in dry gangrene and possible loss of some body extremities.

Infested hay or pasture should also be considered dangerous.

Smutty, Rusted, Sprouted, Moldy, Fire-Damaged, Heated or Frozen Cereal Grains—Grains damaged in any of these ways have reduced palatability and feeding value, although they are seldom toxic to livestock. They are often used most satisfactorily in mixtures with sound grain.

Nitrate Poisoning—Forages containing nitrates may occasionally be fatal to cattle and sheep by interfering with oxygen transport by the blood. The toxic level varies with the amount of grain fed and with the opportunity for adaptation by the rumen bacteria. Deaths have occurred at levels of under 1 percent nitrate when this forage alone has been fed, and 0.5 percent must be considered potentially dangerous. While over 1.5 percent has been tolerated by cattle on heavy grain rations, a reasonable precaution is to dilute the roughage so that the total feed contains no more than 0.5 percent. Roughage from sloughs should be mixed with that from the higher areas where there is less risk of nitrates. The symptoms of nitrate poisoning include difficulty in breathing, with gradually increasing distress as the animal strives for oxygen. Nervousness and lack of co-ordination may be observed. In extreme cases, death may occur within an hour. Animals that appear to recover may suffer some respiratory distress, because of lung damage, for a week or more. Since high levels of nitrate are believed to interfere with utilization of carotene, vitamin A supplements should be fed where nitrates are known or suspected to be at high levels.

Treatment requires the early intravenous administration of a 4 percent solution of methylene blue at the rate of 100 cubic centimeters per 100 pounds body weight.

Frost, drought, and weed sprays may be factors in the increased accumulation of nitrates by plants. Oat straw and oat hay are most often affected. Samples can be analyzed at the University of Saskatchewan, Saskatoon. A sample sent in for analysis should be made up of smaller samples taken from four or five sites in the bin, stack, or silo. A reasonable sample size is 1 pound for grains and 5 pounds for hay or silage. Silage samples should be sealed in an airtight container or double plastic bag to avoid heating or drying.

Prussic Acid or Hydrocyanic Acid Poisoning—Flax that has been frozen or severely affected by drought may contain toxic quantities of prussic acid. Amounts in excess of 0.3 percent to 0.4 percent or 30 to 40 milligrams per 100 grams of dry material (either forage or seeds) are dangerous to feed. Prussic acid, somewhat like nitrates, interferes with oxygen transport by the blood, and the symptoms of poisoning tend to be similar. Treatment must be carried out without delay. It requires intravenous injection of a solution of sodium nitrate and sodium thiosulfate available from a veterinarian or druggist. When there is danger of prussic-acid toxicity, samples of flax should be analyzed and suitable precautions taken. Death usually occurs before treatment is possible. Prussic acid in cured forage gradually disappears and is seldom a problem in late winter.

Water—Poor-quality water sometimes causes difficulty in raising livestock. Water containing 0.35 percent nitrates (see Nitrate Poisoning) is toxic to cattle. Water high in alkali salts may cause unthriftiness by interfering with mineral nutrition. Water with more than 5,000 ppm (parts per million) solids is considered inferior, particularly for young stock. (See Agricultural Engineering section, Farm Water and Sewage, page 33.)

Water contaminated with filth should not be used.

Blue-Green Algae—Algae occasionally reach sufficient concentration in dugouts, lakes, or sloughs to poison livestock. They can be controlled by a uniform application of copper sulphate (bluestone) to provide a proportion by weight of 1 part of chemical per million parts of water, or 1 pound per 100,000 gallons of water, or 1 pound per 16,000 cubic feet of water. Treat water when algae appear or reappear. Treatment is most effective if done in early morning of a sunny day. Alkaline water requires more frequent treatment. Excessive copper sulphate may be injurious to livestock, especially cattle and sheep.

Dicoumarol, "Sweetclover Disease"—Improperly cured sweetclover hay or silage may mold and become toxic to livestock. It should be fed only occasionally or in limited quantities along with good roughage. Excessive bleeding from small wounds results from this type of feed. New varieties, such as Polara and others low in coumarin, do not become toxic with molding.

Pesticides—Certain insecticides and weed sprays are toxic to livestock and may make meat and dairy products unsafe for human consumption. All manufacturers' instructions should be carefully observed. (See Insect Pests section, page 105.)

Paints, Grease, and Oil—Many of the modern lubricants contain toxic components, hence care should be taken to prevent feed from becoming contaminated through grinders, etc., and to prevent livestock from licking machinery or containers.

Poisonous Plants—Death occasionally results when livestock eat poisonous plants. It is advisable to become familiar with the local problems.

Weed Seeds—Feeds containing much mustard seed, lamb's-quarters, pigweed, rapeseed, stinkweed, etc., are low in feeding value. Some "black weed seeds" are actually injurious so it is not wise to regard such material as useful livestock feed.

Replacing Hay with Grain

How much one can afford to pay for hay varies from farm to farm, depending on the kind of livestock and the general relationships between market values, feed costs, etc. For most purposes, hay prices should be assessed in relation to grain prices. Table VII shows the costs per ton of hay and the corresponding values per bushel of grain, both of average quality. For example, if hay is available at 20 dollars per ton and feed barley at 60 cents per bushel, the grain would be the best buy since 60 cents is below the 67-cent equivalent in the table.

Digestive disturbances often occur when too little roughage is fed. In extreme cases of hay shortage, as little as 4 or 5 pounds per day will likely maintain rumen functions in a mature cow, provided the ration contains the necessary minerals and vitamins. Hay, silage, or green pasture is usually relied on for vitamin A. Straw, poor hay, or cereal grains supply none of this vitamin, so it must be added to prevent abortions and to increase disease resistance.

TABLE VII

Price Per Ton of Hay and Corresponding Values Per Bushel of Grain

Price/ton	Price per bu		
	Oats	Barley	Wheat
$15.00	$0.33	$0.51	$0.75
20.00	0.44	0.67	0.98
30.00	0.66	1.02	1.50
40.00	0.88	1.18	1.75

Table VIII gives an example of a daily ration for a 1,000-pound beef cow, in calf, showing various alternatives with ground grain for providing energy needs when good hay is available. Allow minerals in addition.

Straw (oat or barley) may be used along with hay to provide some of the energy requirements of older classes of cattle, but straw contains very little protein, few minerals, and no vitamin A. Feeding mature pregnant cows on straw alone requires the use of about 2 pounds per day of a 32-percent beef-cattle protein supplement or its equivalent to avert heavy calf losses in the spring. Protein supplements should be scaled according to the amount of straw and the quality of hay used. Nutritional needs are most critical with young, growing animals and during pregnancy; and, while some weight losses can be permitted in cows, great care must be taken to avoid shortages of protein, minerals, and vitamin A.

TABLE VIII

Alternatives with Ground Grain for Daily Ration with Good Hay for a 1,000 lb Beef Cow in Calf

Roughage allowance	Grain allowance/day					Dehydrated Alfalfa meal or pellets
	Oats		Barley		Wheat	
Full feed (18 lb/day)	None		None		None	None
½ feed (9 lb/day)	7 lb (10 qt)	*or*	6½ lb (6 qt)	*or*	5½ lb (3 1/3 qt)	½ lb/day
1/3 feed (6 lb/day)	9 1/3 lb (13 qt)	*or*	8½ lb (8 qt)	*or*	7½ lb (4 1/3 qt)	1/3 lb/day

Water Requirements

The livestock enterprise depends on adequate supplies of good-quality water. Water requirements are closely related to feed intake and are influenced by such factors as moisture content of the feed, atmospheric temperatures, and mineral consumption. Normally, the approximate daily water requirements, in gallons, are: Dairy cow, 12 to 15; beef steer, 10; ewe, 1 to 1½; horse, 10 to 12; 100-pound pig, 2; lactating sow, 5 to 6. In planning a livestock enterprise, a water supply three times the basic requirement should be available.

Mineral Supplements

Only a few minerals will likely need to be added to those ordinarily contained in farm rations.

Salt—Cattle, sheep, and horses should have access to salt at all times. It may be included in grain rations for these animals and swine as indicated in Table V.

Calcium and Phosphorus—These are needed especially by growing animals and by females during lactation. If legume forage is fed, the calcium needs are likely to be met for cattle, sheep, and horses. Protein supplements (especially those of animal origin), grain, and wheat bran contain more phosphorus than do hays. In general, however, for satisfactory growth and reproduction, additional calcium and phosphorus should be provided. Cattle may be given access to bone meal alone, or mixed with salt, or added as 1 percent of the grain mixtures. When legumes are not fed, dairy cows should receive ½- to 1-percent ground limestone with grain to supply calcium. Some of the calcium and phosphorus needs of pigs will be met if either skim milk, buttermilk, tankage, or meat and bone scraps are fed in amounts recommended to meet protein requirements. However, a further allowance of bone meal and ground limestone will ensure better development of young pigs.

Iodine—This is needed particularly by pregnant and lactating females. A deficiency leads to the birth of hairless pigs, goitre in newborn calves and lambs, and weak foals. Feeds grown in Saskatchewan do not contain adequate amounts. Iodized salt (see cobalt below) should therefore be used in preference to plain white salt. The iodine in iodized salt is "stabilized," yet much of it will be lost in a few months of exposure, so new supplies should be provided frequently. As an added precaution, pregnant mares and sows should be given daily 1 tablespoon of a solution containing 1 ounce of potassium iodide in 1 gallon of soft water.

Cobalt—This may be deficient in certain areas. Lack of it appears to affect only cattle and sheep. Affected animals appear unthrifty in spite of adequate feed intakes and proper supplies of protein, salt, calcium, and phosphorus. The use of cobalt-iodized (blue) salt is generally recommended for cattle and sheep.

Iron and Copper—These are usually abundant in average farm feeds but they may be inadequate for sucklings.

Zinc—Parakeratosis, a mange-like skin condition of growing pigs, appears to result from excessive calcium. The addition of zinc sulphate to the ration is recommended as a preventive. The level required is about one-third ounce per 100 pounds of complete feed, or about 2 ounces per 100 pounds of protein-mineral supplement. Most commercial hog supplements now contain the necessary zinc.

While all of the minerals just mentioned are available in commercial mineral feeds and in certain protein-mineral supplements, the mixtures listed in Table V will supply the needs of farm animals. It is advisable to self-feed minerals to cattle, sheep, and horses. Minerals may be self-fed to swine but prepared protein-mineral (minimum 32 percent protein) supplements used according to direction will ensure better nutrition and are recommended as follows: 1. Two percent in rations for pigs up to 100 pounds; 2. 1½ percent for pigs 100-200 pounds; 3. 2 percent for pregnant sows; 4. 1 percent in high-grain rations; 2 percent to 3 percent in grain portion of high-roughage rations.

Mineral mixtures of the types described usually cost under $7.00 per hundredweight. The incorporation of vitamins, drugs, etc., is often too costly. Further advice should be obtained before investing in feed supplements that may be unnecessarily costly and complex.

TABLE IX

Mineral Mixtures for Farm Livestock

Mineral	Swine	Beef, dairy cattle, sheep, horses	
		High-Roughage Ration	High-Grain Ration
	(lb)	(lb)	(lb)
Bone meal dicalcium phosphate, or defluorinated rock phosphate	50	70	30
Ground limestone	30	—	40
Iodized salt	20	—	—
Cobalt iodized salt	—	30	30
Zinc sulphate	1.5	—	—
Ferrous (iron) sulphate	0.5	—	—

Antibiotics

Antibiotics such as aureomycin, terramycin, penicillin, and streptomycin are available in antibiotic feed supplements. Many of the commercial protein supplements and complete mixed feeds for young pigs, calves, chicks, and broilers contain appropriate kinds and levels of antibiotics. The feeding of antibiotics to these classes of livestock and poultry increases rate of gain, improves feed efficiency, and eliminates or reduces digestive disturbances such as scours or diarrhea. Their use, however, does not eliminate the need for proper sanitation and feeding practices. Antibiotics should not be fed indiscriminately, since resistant strains of bacteria may develop. It is best to confine their use to rations for young animals, and to conditions such as scours for which they are specifically indicated.

Where antibiotic supplements are to be mixed on the farm, up-to-date recommendations should be obtained about the kinds and levels required. Variations in potencies of products and between classes of livestock make general recommendations difficult to provide.

Vitamin Supplements

Although animals require ten or more different vitamins, it is often unnecessary to add them to the ration. Vitamin A, however, may be lacking when low-quality roughage is fed to cattle, sheep, and horses. If so, a vitamin A supplement will be needed. Ruminants can produce the necessary B vitamins in the rumen, provided the diet is normal for protein, minerals, and energy.

Vitamin preparations vary considerably in cost and complexity. It is important that feeding practices be based on the recommendations given for each particular class of livestock and that appropriate vitamin supplements be included only where specifically indicated. The cost of vitamin supplements, in relation to their potency, should always be closely examined.

Processing Feedstuffs

Grain—Grinding increases the surface area of grain, increasing digestibility and making mixing easier. (See Table X.)

The hammer mill is best for producing a finely ground product and has the added advantage of being able to grind roughages. A plate mill is favored for coarse grinding and for producing a uniform particle size.

TABLE X

Grain Grinding Recommendations

Grain	Calves to 6 months	Older cattle	Sheep	Swine
Barley	coarse or rolled	coarse or rolled	whole	medium fine
Oats	whole	coarse or rolled	whole	fine
Wheat	coarse or rolled	coarse or rolled	whole	coarse

Roller mills for crimping either dry or steam-conditioned grain are increasing in use, particularly with high-concentrate rations for fattening beef cattle. It is generally agreed that dry-rolling grain for fattening cattle leads to fewer digestive upsets than grinding. Steam rolling is superior to both.

Separate and combination grinding and mixing machines are available but the costs of on-the-farm processing must be considered in relation to the total tonnage being produced. In some cases it may be more economical to make use of commercial milling equipment. (See Agricultural Engineering section, page 19.)

The very high cost of pellet mills limits them to commercial rather than on-the-farm operations. Livestock producers must carefully consider costs before paying for this extra processing.

Pellets or crumbled pellets (crumbles) are recommended for suckling and weanling pig rations; they are not economical with all-concentrate beef and sheep rations.

Roughage—Despite a common opinion to the contrary, cattle and sheep can make reasonably rapid gains and attain an adequate finish on rations containing as much as 80 percent ground roughage (⅜- to 5/16-inch screen). Grinding and pelleting of high-roughage rations will increase their density, enabling animals to eat enough to produce satisfactorily. Feeder cattle and lambs can be self-fed high-roughage rations immediately after going into the feedlot. If bloat occurs on high-quality ground hay (usually alfalfa), replace one-third of it with straw.

Chopping roughages (2- to 4-inch cut) reduces waste, particularly of poor quality, stemmy material, and saves labor, since the feed can be blown into storage. However, some mature forage, such as crested wheat, may be left with sharp ends that irritate the mouth and throat. Spontaneous combustion is a danger in chopped roughage if the moisture content is over 15 percent.

Grinding permits the mixing of two qualities of roughage to balance the nutrients and encourage consumption of the less palatable one. Grinding also permits mechanized handling as well as the mixing in of supplements with little settling out of ingredients. In some types of mixers and feeders, ground roughages bridge and may become dusty. If dustiness reduces palatability, the roughage can be moistened with dilute molasses or water. (Mix the molasses and grain first to avoid lumping.)

Processing high-roughage rations may become uneconomical, particularly when using custom or mobile mills that charge by the mix.

Feeding ground roughage to dairy cows tends to reduce the butterfat level in the milk. Horses fed ground roughages may develop "heaves," a respiratory disorder.

Pelleting minimizes dustiness, reduces losses during feeding, and improves handling quality. Although pelleting usually increases feed consumption and efficiency of gain, the cost of transporting and processing may not be justified.

Feeding Silage

The nutritional value of well-preserved silage is comparable on a dry-matter basis to top-quality hay from the same crop. Ensiling improves the palatability of weedy crops or coarse or stemmy forages such as sweetclover. The nutrient content will vary considerably from one crop to another, so an analysis will be needed to formulate rations accurately.

The amount of silage required to substitute for hay will depend on the moisture content of the silage. (See Table XI.)

Silage is a bulky feed. Some livestock, particularly young animals, may not be able to consume enough to meet their nutrient requirements, and they may need a hay or grain supplement. It is important to keep the moisture content at the minimum for proper ensiling. (See Forage Crops section, page 58.)

TABLE XI

Hay to Silage Substitution

Forages	Moisture content	Dry matter	Lb silage to replace 1 lb hay
Hay	10%	90%	—
Silage	80%	20%	4.5
Silage	75%	25%	3.6
Silage	65%	35%	2.6
Silage	55%	45%	2.0

Hand Feeding—In small herds silage is most economically fed when forked by hand into a small truck or wagon. In larger herds a front-end loader may be practical. For unloading, a manure spreader with the beaters removed or a homemade unloading wagon, is useful. Where large quantities of silage are handled, a front-end loader and power feedbox are a good investment.

Self-Feeding—Self-feeding is not generally recommended unless the silo has a cement floor and is cleaned frequently.

Automated Feeding—Upright silos, automatic silo unloaders, and auger systems may be economically installed on specialized feeder or dairy operations.

FEED TESTING SERVICES

A full range of feed testing services is now available at the University of Saskatchewan. A new laboratory, operated by the Animal Science Department, offers analyses for crude protein, estimated digestible energy, essential minerals and vitamins, and for toxic substances such as nitrates and prussic acid. Fees vary depending on number and kind of analyses, and are in accordance with actual costs involved.

If laboratory analyses of feeds are to be meaningfully interpreted for livestock producers, it is essential that samples be properly taken, and that they be accompanied by detailed information about the use to which they will be put. Sampling devices and information sheets are available from agricultural representatives, livestock extension specialists, and other persons involved in servicing the livestock industry.

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ANIMAL DISEASES

One of the most unpredictable factors associated with livestock management is the effect which disease will have on future production. It is important to recognize that losses due to livestock deaths may only represent a small part of the overall cost which can be attributed to any disease problem. Production losses through impaired performance are often overlooked when costs of an outbreak are evaluated.

Each disease has an appropriate treatment and control program. It is invariably more economical to prevent a disease rather than be forced to initiate treatment after one has been established.

Veterinary service is now generally available to livestock owners in Saskatchewan. A veterinarian should be consulted in the management, treatment, and control measures and also in designing disease prevention programs. Too many animals die or become uneconomical producers because veterinary assistance is sought too late or not at all.

With the increased international exchange of people, livestock, and livestock products, the risk of introducing exotic diseases represents an additional threat to the Saskatchewan livestock population.

A number of animal diseases recognized to be present in Saskatchewan livestock are known to be communicable to man. These diseases have been identified in this section by an asterisk (*).

The livestock producer working with his veterinary practitioner represents the first line of defence in the control and eradication of livestock diseases.

Approximately 80 practitioners directly serve the livestock industry in Saskatchewan. These veterinarians work together with veterinary personnel such as the staffs of the Health of Animals Division (C.D.A.), the Provincial Veterinary Division, and the Western College of Veterinary Medicine at Saskatoon towards rapid diagnosis and treatment as well as prevention of livestock diseases in the province.

A list of veterinary practitioners and an outline of veterinary services are presented at the end of this section.

GENERAL CONSIDERATIONS

Preventive Medicine Programs

In recent years there has been a noticeable trend, particularly in large production units, to institute disease prevention programs as opposed to administration of treatment after a disease has become established. The advantage of this approach is too obvious to require "selling." Many livestock producers have instituted the practice of employing veterinary supervision of their herds and flocks on a regular basis. The true effectiveness of a herd health program will only be recognized if complete records of production are maintained.

Predisposing Causes

Many diseases are contracted or aggravated by animals being exposed to conditions of stress such as severe weather, shipping, decreased feed intake, lack of water, pregnancy, heavy production, dehorning, and castration. When possible, conditions which will cause stress should be controlled. For example, select suitable weather to castrate, dehorn, and vaccinate rather than force the animals to endure a number of stress situations in a short period of time.

Treatment

The indiscriminate use of drugs can be costly and even dangerous. The administration of certain medications will render some carcasses unfit for human (or animal) consumption. Since the advent of antibiotics, a startling number of strains of bacteria have developed resistance to these antibiotics. Thus the drugs are often found to be ineffective when needed to control serious infections in animals or man. Perhaps the most serious consequence of using some drugs injudiciously is the buildup in edible animal tissues of residues which are dangerous to the consumer. Also, many drugs are harmful if used in combination with other drugs. In all cases of doubt, consult expert advice.

The most effective disease control methods may not come from a pill bottle or be found under an antibiotic umbrella. Sound management programs which adopt principles of animal husbandry are still the most effective methods of controlling animal disease.

DISEASES OF IMPORTANCE FOR ALL CLASSES OF LIVESTOCK

Anthrax*

Anthrax is a disease which affects virtually all animals, including man. While uncommon in Saskatchewan, it does occur. One of the striking characteristics of anthrax is the fact that death occurs very rapidly. Often victims die without showing any previous signs of illness.

Anthrax is caused by a germ which has the ability to form spores when exposed to air. The organism forms spores by developing a thick wall which protects it from extremes of climate and most disinfectants. Spores have been known to lie dormant in the soil for many years and still cause infection.

It is generally believed that spores do not form in the unopened carcass. Therefore, if an animal is expected to have died from anthrax, **do not cut the carcass** in any way. Anthrax has dangerous public health implications and should be handled only by experienced personnel.

Sudden and unexplained deaths in animals should be reported to a veterinarian so that the cause can be determined.

Premises under suspicion of anthrax are quarantined by federal authorities, who supervise disposal of carcasses, disinfection, and vaccination of livestock which may have been in contact with an infected animal.

An indemnity based on current market values up to a specified maximum is paid for cattle, sheep, horses, and swine that have died of anthrax in order to minimize the loss experienced by livestock owners because of this disease.

Rabies*

Rabies is a disease which affects all mammals. It is caused by a virus and affects the nervous system. Animals affected with this disease must be handled with extreme care. Rabies is transmitted from animal to animal by means of a bite introducing the virus-bearing saliva. Virus may be present in the saliva and transmitted by an infected animal several days prior to the onset of clinical signs. Wildlife, mainly skunks, are responsible for spreading the infection to farm animals.

When suffering from rabies, animals are either excited and savage, or else abnormally quiet and docile.

Wild animals that normally avoid people may act strangely and even appear tame. Children should be warned to report such circumstances to an adult and not to attempt to touch or even approach a sick wild animal.

In cattle, the signs of rabies are indefinite. Sometimes affected cattle appear to have an object lodged in their throat. Dullness with a changing voice are early signs. Examining such animals has often resulted in farmers and their families being dangerously exposed.

An animal suspected of having rabies should not be shot through the head, especially if there is a history of human exposure. The brain of the animal is needed for diagnosis.

Suspected cases of rabies should be reported to a veterinarian or a member of the R.C.M.P.

Poisons and Toxic Materials in Feed

For information on this subject, see Livestock section, Feeding Livestock, Special Feeding Problems, page 149.

Diseases Caused by Insects

For discussion of these problems, see Insect Pests section, page 105.

DISEASES OF CATTLE

Infectious Diseases

Blackleg and Malignant Edema—Most stock owners are familiar with these conditions which are common killers of cattle up to 3 years of age. Older cattle are affected occasionally. They can be rapidly fatal and the first indication of disease may be the finding of a bloated carcass with a bloody discharge oozing from the natural body openings. Gas can often be felt under the skin, usually in the quarter region over an affected leg. Signs in the living animal include lameness, severe distress, and collapse, with the animal lying on its side, stretching, and groaning. The possibility that other diseases are present (e.g., anthrax) should be eliminated by consulting a veterinarian. Vaccination is very effective and all cattle should be inoculated routinely with a combined blackleg malignant edema bacterin at about 3 to 4 months of age and again as yearlings. Sometimes local conditions require them to be vaccinated earlier than at 4 months; in such cases they should be re-vaccinated at about 6 months. If malignant edema is the main problem, the herd should be re-vaccinated each year.

Brucellosis* (Bang's Disease or Contagious Abortion)—This disease has almost been eliminated by blood testing and the slaughter of reactors under the federal government's Brucellosis Control Area program (B.C.A.). All rural municipal units in the province have qualified as brucellosis certified (less than 1 percent infection) and most have qualified as brucellosis free (less than two-tenths of 1 percent infection).

The vaccination of calves against brucellosis played a very important role in the initial stages of the control and eradication programs but, as total eradication approaches, the use of the vaccine is not generally recommended. Vaccination is discouraged in brucellosis-free areas and its use has been prohibited in federal government herds. Owners should be guided by their veterinarians when deciding on the use of vaccine in their particular herd. The age for vaccination is from 3 to 9 months and within this age, the younger the calf the better.

Since there are a number of causes of abortion in cattle, stock owners are urged to report cases to a veterinarian referred to at the end of this section. It is most important that all such incidents be investigated in order to stop the spread of brucellosis or other infectious agents causing abortion.

The Health of Animals Branch, Canada Department of Agriculture, is continuing its campaign to rid the country of brucellosis through routine blood testing and special screening test programs listed below.

All breeding cattle over 3 years of age are back-tagged at stockyards and other assembly points. Some are shipped for slaughter and blood tested at the abattoir while others not going for slaughter are tested at the stockyard before being released (Market Cattle Testing Program).

Milk and cream samples are collected at creameries and dairies three to four times a year and submitted to test for brucellosis to determine whether or not there is infection in the patron's herd. This is the Brucellosis Ring Testing Program.

These two programs constitute a sort of "watch dog" procedure so that potential outbreaks can be detected in the early stages and the spread of the infection avoided. Many herds not covered by either of the two above-mentioned screening programs are submitted to routine on-the-farm blood tests.

Calf Scours (Neonatal Diarrhea)—Calf scours is a sign of disease rather than a specific disease entity. Bacteria, viruses, and viruslike organisms, and improper feeding alone or in combination can all cause young calves to scour. The most common cause of what is sometimes called "white scours" is believed to be a bacteria.

The problem is most common in dairy herds during the winter months when calves are confined to group pens and where overcrowding and sanitation are a problem. In beef herds losses to scours are worst during the spring calving season. Wintering and calving cows in overcrowded, wet, dirty areas can lead to a buildup of infection which can cause each new calf to become sick soon after it is born.

Sick calves can die suddenly (12 hours) without showing outward signs of scouring. This usually occurs when the bacteria get directly into the blood through the navel or mouth soon after birth. In other calves the infection is localized in the intestines. These calves usually scour but can also collapse and die quite quickly with scouring seen only just before death. The most common form encountered in Western Canada is that in which calves begin to scour anytime during the first 10 days of life. They may remain strong enough to continue sucking for one to several days but the scours persist. During this time, they lose water, minerals, vitamins, and energy necessary for growth and resistance to further infection. Sooner or later, they collapse from dehydration and weakness, and death follows. Calves which survive a bout of scours usually remain unthrifty for a variable period. Arthritis can appear for several weeks after. Loss of body hair is also a common finding.

Any of the above can occur either in the individual or as a herd problem. Vaccination is not a satisfactory means of control. Prevention revolves around good management and feeding procedures which include the following: 1. Good nutrition of the dam. This will insure strong, healthy calves which will suck early and have greater disease resistance; 2. good sanitation in the calving area. Cows should not calve in the same area where they have wintered, because there is a buildup of bacteria in manure and bedding. Clean, dry bedding should be put down at calving. If calving occurs early in spring and the weather is poor, provide some shelter at least from wind. Dairy cows should calve in a clean, dry box stall which is disinfected between calvings; 3. be sure calves are given colostrum early—at least in the first 5 hours. Colostrum is very important for resistance to disease as well as high levels of vitamin A; 4. if calves are pail-fed, use clean utensils and feed a regular amount at regular times; 5. calves kept indoors should be housed in separate pens. Group pens allow for rapid spread of disease; 6. sick calves spread disease. They should be isolated and treated early.

Treatment depends on the severity of the condition. If still standing and sucking, the calf should be removed from milk for 12 to 24 hours. Commercial preparations are available which can be given by mouth and which supply the calf with fluid, energy, and body elements. If the calf is down and dehydrated, it should receive intravenous fluids. Antibiotics are generally used but should **not** be relied on in all cases, since not all scours are due to antibiotic-sensitive organisms.

Coccidiosis—This is an infectious, bloody diarrhea mainly of young animals kept in crowded quarters. It is frequently a feedlot problem. The parasite responsible thrives in wet places and in unsanitary conditions. Diagnosis may be confirmed by microscopic examination of fecal samples. Sulfonamides and intestinal astringents are used in treatment, but prevention is more satisfactory.

Foot Rot—This is common in cattle whether in pens or on pasture. Its spread is favored by wet, dirty surroundings in areas where animals tend to congregate. Animals with cracks or injuries in their feet are more susceptible. A concrete standing platform around water and feeding troughs is worthwhile when foot rot is a problem. Control is particularly difficult on ranges or community pastures, and the disease occurs frequently in animals on dry-summer grazing. The feeding of an organic iodine compound mixed with salt has become popular in recent years as a preventive. This treatment is questionable and the main value would appear to be that iodine is required as a trace element, and for general health reasons its inclusion in the ration is beneficial. In Saskatchewan, a mineral supplement to provide calcium and phosphorous, summer and winter, is required for healthy foot development. Early treatment is essential. Although separation of diseased and healthy stock is desirable, it is not always practical. Antibiotic injections or sulfa drugs used in the very early stages will usually cure foot rot. Permanent disability can result in untended cases.

Infectious Bovine Rhinotracheitis (IBR)—This is primarily a respiratory disease accompanied by fever and marked by coughing and profuse nasal discharge. It is most often observed in feedlot cattle but can be a problem in dairy cattle and sometimes in calves. It is caused by a virus. Other effects associated with the virus are now being recognized in Saskatchewan and abortion may be one of the sequels in a breeding herd. It is important to keep pregnant animals away from a feedlot operation or from contact with animals purchased in the fall. This is especially true if there is evidence of respiratory disease in the feedlot or the new additions. Carriers of this virus may come down with respiratory disease following the stress of shipping. Once abortion starts, nothing can be done to control it and the number of abortions in a herd can vary from as low as 2 percent to as high as 70 percent.

The IBR virus is also responsible for scouring problems in newborn calves. Response to treatment is very poor, resulting in a high death rate.

The virus is sometimes associated with an inflammation of the reproductive organs of the bull and cow, causing a temporary interference with breeding. It is not serious and recovery usually occurs without treatment. Other side effects of IBR may be a pinkeye-like condition which can occur by itself but is seen more often as a complication of the respiratory form. Infection of the brain of older calves has also been recorded but is not common.

No treatment is available for the uncomplicated respiratory disease which will clear up in a few days without medication. Treatment will help to control secondary invading bacteria when these become significant.

Vaccination of empty females about a month before being bred is recommended for the prevention of abortion. Use of the vaccine in pregnant animals can give rise to abortion. Vaccination should be done only under professional supervision using a modified live virus one-way vaccine.

Vaccination for the control of the respiratory form of IBR appears to be less effective; nevertheless it is widely used. It should be emphasized that these are live-virus vaccines and extreme care must be exercised when handling them. Several types are available and a veterinarian should be consulted in regard to the product of choice. There are two-way and three-way vaccines containing other viruses and complications have followed their use. It is important and worth repeating that vaccination should be done only under professional supervision.

In order to control this disease, purchased animals should be kept isolated for a week to 10 days before being placed with the rest of the herd.

Johne's Disease—This is a chronic, infectious disease of cattle and sometimes of sheep and goats, characterized by a recurrent diarrhea which may persist for months, causing a gradual loss of flesh. With few exceptions animals showing symptoms eventually die. Diagnosis is often difficult.

The disease is not widespread in Saskatchewan but is responsible for serious losses in some herds.

The Health of Animals Branch, Canada Department of Agriculture, has introduced a Johne's Disease Tested Herd Policy, which is a voluntary program designed to assist livestock owners who are experiencing losses due to this disease. Reactor animals are ordered to be slaughtered and compensation is paid in accordance with the regulations of the Animal Contagious Diseases Act.

A vigorous sanitation program designed to prevent contamination of feed given to calves with feces from older cattle will significantly reduce losses from this disease.

Lump Jaw—Lump jaw is an infectious disease characterized by a hard swelling on the side of the face. The seat of the infection is in either the upper or lower jawbone, but it may involve the soft tissues as well. The disease is chronic in nature and the animal may do well until the teeth are involved. At this time, the animal will likely go off feed and lose condition. Affected animals should be treated as early as possible to arrest the infection before the teeth become involved. Older treatments are relatively inefficient, but a new drug, "Isoniazid," appears to be effective. The animal should be isolated and the drug added to its feed for 21 to 30 days. The treatment will not correct changes in the bone present but will halt further spread of the condition. Severe cases, where the teeth are malaligned or where gross disfiguration of the face occurs, should be isolated and disposed of because they do not respond well to treatment. The large swellings commonly break open and drain pus which contaminates pastures and feed troughs. The disease is not highly contagious but will spread slowly to other animals in the herd.

Mastitis—This is the most important disease of dairy cows. It is infectious. Many different micro-organisms can cause mastitis if they get into the udder. It is most often caused by either Streptococci or Staphylococci. The two organisms may occur together. Infections producing mastitis invade the udder through the teat openings.

Predisposing causes are very important. Teat injuries provide entry for infection. Rough thumb and finger stripping or milking-machine cups that are allowed to "creep" on an empty udder cause damage to the teat and the lower milk cistern. Mastitis infections gain an easy foothold in these damaged tissues.

Mastitis is a complex and difficult disease to prevent and control. Owners should be careful not to introduce infected cows into clean herds, or when setting up new herds. Complete recovery is not possible unless treatment is begun in the early stages. Keeping the disease under control demands continuous vigilance for early signs.

The California Mastitis Test (CMT) is popular. It is not satisfactory in cows freshened less than a week, or which have been milking more than 270 days. The CMT is a very sensitive indicator of inflammation of the udder but it cannot tell the cause. Udder irritations due to improper milking will result in positive reactions, as will inflammation from bacterial infections. A positive reaction indicates that the cow should be kept separate from the rest of the herd at milking time, and a milk sample should be sent to the laboratory for examination. Treatment is not carried out unless clinical signs of mastitis develop or the laboratory

report is positive and recommends treatment. If laboratory services are not readily available, a positive CMT on successive days might indicate the need for treatment but, at the same time, a thorough check should be made of management and milking techniques.

Infected cows should be placed at the end of the milking line and milked last by hand. Milking onto the floor should be avoided. The milk from infected quarters is not fit for human consumption and should be discarded in a safe place. The hands should be thoroughly washed in soap and water and disinfected in chlorine solution after handling infected udders. After milking, use an efficient disinfecting teat dip. Treatment is best left to a veterinarian. The drugs used may be shed in the milk for several days following treatment. Such milk is not fit for use. Mastitis preparations are obtainable in tubes to administer through the teat openings. Accompanying directions should be strictly followed.

The basis of any satisfactory mastitis control program is strict attention to sanitation and milking procedure.

Mucosal Disease (Bovine Virus Diarrhea Complex)—Fever, nasal discharge, and diarrhea are the principal signs. Affected animals commonly will have ulcers on the tongue, palate, and lips. The death rate among affected animals is very high. While a vaccine is available, the sporadic nature of outbreaks limits its use to special circumstances and veterinary recommendation. The practice of isolating animals for at least 1 week after their arrival on the farm helps to prevent introduction of the disease to the home herd.

Pinkeye—This disease, usually associated with the fly season, comes suddenly, may infect one or both eyes, and may spread rapidly through the herd in either pastures or feedlots. Affected cattle are sensitive to light and show eye discharge. A whitish film usually forms over the eye surface. Treatment with one of the many eye sprays or ointments containing antibiotics and designed for the purpose is often successful. These are preferred to powders because the infected eye is very sensitive and is susceptible to additional drying and irritation. Care should also be taken to avoid spreading the infection from infected to noninfected animals. A promising development is an ointment containing an insecticide and repellent which is smeared around the eyes and provides protection from insect carriers of the infection. (See Insect Pests section.) In severe and untended cases, total blindness may result from destruction of the deeper structures of the eye. Whenever possible, affected animals should be isolated and protected from wind, dust, sunlight, and flies. Some immunity is present following recovery from the disease. The existence of carrier animals makes prevention difficult.

Severe cases require the attention of a veterinarian. At present, available vaccines have not proven to be of significant value.

Ringworm*—This is usually a winter disease in cattle crowded into close quarters that have not been properly cleaned and disinfected. Infection can survive in buildings over the summer to re-infect stock after they are stabled in the fall. The disease usually clears up when cattle go out to pasture in the spring. Iodized mineral oil or tincture of iodine can be used for treatment and newer or more potent remedies can be obtained from a veterinarian. Ringworm can infect people.

Salmonellosis—The principal signs of this infectious disease are severe watery diarrhea, depression, and fever. In very young animals, nervous signs may also be present. This disease affects all ages and species of livestock, with the highest mortality in young animals. Salmonellosis is commonly precipitated by a stress situation such as calving, shipping, feed and management changes, or another disease.

Specific antibiotics when given early will reduce death losses, but recovered animals may remain carriers of the bacteria. Vaccines are not commonly used except in specific herd problems. Treatment and control techniques appropriate to the specific situation are best obtained from a veterinarian.

Shipping Fever—This is an acute, highly contagious disease of cattle, characterized by high fever, pneumonia, and sometimes scouring. Vaccination in the past has been of limited or no value, but new vaccines are being tested. In the meantime, owners can do much to minimize the risk of infection by sensible handling of animals in stockyards and during transit. Exhaustion from travel, draughts, and rough handling may lower resistance and allow an outbreak. Shipping calves shortly after weaning is asking for trouble. Operations such as weaning, branding, vaccinating, and dehorning should be intelligently spaced, especially during unfavorable weather conditions. Many people claim good results from the administration of drugs before shipment to distant points. Some injectable antibiotics, however, can cause shock and occasionally animals have been lost. Sulfa drugs are also used and in treatment sulfamethazine is usually recommended. On arrival at their destination, always make certain that stock which have been shipped drink plenty of water, and keep them separate from other animals for at least 2 weeks. Failure to do this has resulted in severe outbreaks in herds without any stress conditions being present.

Tuberculosis*—Bovine tuberculosis has almost been eliminated through the test and slaughter program that was introduced on an area basis by the Health of Animals Branch, Canada Department of Agriculture, several years ago.

In order to keep the disease under control and to maintain the health standards necessary for Canadian cattle to qualify for export to other countries, tuberculosis tests must be conducted regularly in keeping with the Tuberculosis Restricted Area Regulations. Positive tests to tuberculosis are sometimes encountered where cattle and poultry or swine are confined together.

In addition to regular on-the-farm testing, a screening program has been developed whereby cattle identified under the Brucellosis Market Cattle Testing program are examined for evidence of tuberculosis at federally inspected abattoirs. When an owner has had sufficient numbers of his cattle examined by this method, it may be possible to exempt his herd from test.

Federal veterinarians also carry out mass testing programs at community pastures, wherever possible, in order to eliminate the time-consuming and costly procedure of on-the-farm testing.

Note: Avian tuberculosis, which affects poultry and swine in particular, is still prevalent in some areas. Where infected poultry and swine are raised in contact with cattle, the cattle may become infected.

Vibriosis—This infectious disease which causes early abortion is spread by the bull at the time of service. It often appears to be a fertility problem because abortions occur very early. Failure of a number of cows to conceive and return of others to service at irregular intervals are typical. Infection in bulls, especially older bulls, is usually permanent, although some cases have been treated successfully. Most females recover if they are not bred for three successive heat periods, but the recovery period is shortened and a complete cure is more probable if the uterus is treated with an antibiotic solution.

Proper management of the breeding herd will control and eventually eliminate vibriosis. One method is to use virgin bulls on the heifer herd. However, this may be impractical under range conditions, because two herds must be maintained to separate infected animals from healthy ones. In many cases, artificial insemination is a more economical solution.

A vaccine which has proven to be of value is produced commercially. It has been widely used on community pastures where artificial insemination and other recognized means of control are not easy to carry out.

All females should be vaccinated with a commercially available vaccine at least 3 weeks before they are placed in the breeding herd.

Personal discussion is necessary before advice on control, appropriate to a specific situation, can be given. Preventive

measures should be planned carefully because symptoms of the disease are not dramatic and often are not detected until after serious economic losses have occurred.

Warts—Warts in cattle are familiar to most stock owners. They are infectious and are most often found in calves and yearlings, particularly during the late winter months in animals that have been stabled. They tend to clear up spontaneously in the early spring after the stock have been turned out. Small warts can be clipped off with scissors. Sometimes massive areas of skin become involved prohibiting surgical treatment. In such cases a vaccine can be tried and, where circumstances warrant, a vaccine from wart material can be made at the Veterinary Laboratory in Regina or the Western College of Veterinary Medicine in Saskatoon. The proper tissues must be sent in by a veterinarian.

Winter Dysentery—A highly contagious disease of adult cattle. The disease spreads very rapidly through a herd, causing a severe diarrhea. Cattle become dehydrated and drop markedly in milk production and condition as a result of the diarrhea.

The disease is associated with a relative of the Vibrio organism which causes abortion. Research has indicated that one or more viruses may also be involved in the disease.

The disease commonly runs its course in 2 to 3 days. Treatment is directed at restoring body fluids and electrolytes lost through the diarrhea.

No specific preventive measures are known.

Wooden Tongue—The cause of this disease is a germ similar to the one that causes lump jaw. This germ usually attacks the soft tissues of the head especially the tongue. The disease is acute in onset and the tongue is very sore; therefore, the animal refuses to eat. In some cases, the animal may die of starvation. The results of treatment are usually very good, especially if given early in the disease. Standard treatment is sodium iodide given intravenously, followed by daily doses of potassium iodide; however, these drugs should be used with caution, as they can be dangerous. Sulfonamides and antibiotics are also used. Proper treatment given early will prevent permanent damage to the tongue and the severe weight loss which accompanies this condition.

Non-Infectious Diseases

Acetonemia (Ketosis)—Acetonemia is another common disease of the dairy cow. The disease is usually seen 1 to 4 weeks after calving and is particularly common in late winter and early spring. Acetonemia is not always a separate disease but it may occur as a complication to another disease. The disease is characterized by a lack of appetite, drop in milk production, and rapid loss of body condition. A peculiar sweetish odor may be noted on the cow's breath or even from her milk. Occasionally, nervous symptoms, such as licking the manger or the forelegs, staggering, or even convulsions will be seen, but these cases are rare. The affected cows pass acetone in their urine which can be tested to substantiate the diagnosis. The treatment is usually glucose or other agents intravenously and propylene glycol given as a drench for 4 to 5 days. The prevention of this disease is largely based on the feeding program before and after calving. The cow should be on a good-balanced ration and the ration should be maintained in late pregnancy. Once the cow has calved, she should have her feed increased to match her expected increase in milk production. Most cases of acetonemia are a result of insufficient energy intake. High-producing cows should be on a high-energy ration and this fed carefully. Cows that are housed should get some daily exercise as this also helps prevent the disease. Also, cows should be turned to pasture early in the spring if possible. If the disease is a particular problem with a single cow, one could breed her to have her calf when she is on good pasture.

Acute Pulmonary Emphysema—Cattle placed on or changed to new pasture, usually more succulent and fast growing, without being required to eat dry fodder or coarse roughage, may be affected by this disease within 7 to 10 days. Calves do not get this disease. In Western Canada, it usually occurs in outbreak form in late summer or early fall.

Affected animals may be found dead. Others, still living, breathe with great difficulty, often with an expiratory grunt; many may die from suffocation. They should not be forced to move or be driven, since activity increases their need for air and more will die. If it becomes essential to get the animals to shelter, do so as carefully and slowly as possible.

At post-mortem, the lung tissue is found to be distended with air bubbles interspersed with fluid.

The condition may be prevented by changing animals to new pasture gradually—a few hours on, then equal time off with only dry fodder, for the first few days. Time on new pasture is increased as animals adapt to the new diet. The condition may be prevented by distributing dry roughage in the pasture, since animals will usually eat such material voluntarily.

Bloat—This condition is due to an accumulation of gas in the rumen or paunch. It is a form of "indigestion" and in Saskatchewan mainly occurs in feedlot animals and animals grazing on green pasture, particularly if alfalfa is present. An overload of grain and the consumption of frozen vegetation or moldy food are at times responsible. There are also various physical causes, such as injuries to the stomach, choke, and occasionally growths.

In "frothy" bloat, the gas is mixed with the rumen contents.

Acute bloat can be rapidly fatal. Every year, a large number of Saskatchewan cattle are lost as a result of this condition.

Emergency treatment may be necessary to save the animal's life. Tapping the rumen with a trocar and cannula or even a knife may keep the animal alive while awaiting professional assistance. Drenching with mineral oil or preferably vegetable oil is helpful. Although medicines such as turpentine, creolin, coal oil, and formalin are frequently used, they are of less value and an overdose can be dangerous. When drenching bloated animals, special care must be taken to avoid pouring the liquid down the trachea (windpipe).

Cattle owners should ensure that a bloat remedy is always on hand for emergency use. Familiarization with the correct location to tap the rumen is recommended. This information may be obtained from a veterinary practitioner.

Downer Cow—This condition can be a complication of many diseases that cause the cow to be down for several days. The most common are milk fever and obdurator paralysis. The cow may recover from the original disease but is unable to get up. In most cases, cows cannot rise because of severe muscle and nerve damage to the hind limbs. This damage is believed to be due to an interference with the circulation of the limb. This interference with circulation is a result of pressure on the limb and/or cold floors next to it. Most commonly, this condition occurs when heavy cows are recumbent in the barn, usually on cold, wet concrete floors. It is especially bad when there is little bedding or when the cow's hindquarters are hanging back into the gutter. Although there is no specific treatment for this condition, the following suggestions will help: 1. Roll the cow from one side to the other every 4 to 6 hours and massage the hamstring muscles well after each rolling; 2. provide ample bedding; 3. raise the cow gently several times every day, using lifters placed on the rump. In any event, veterinary advice should be sought as skilled attention is called for.

Prevention of the "downer cow" syndrome includes the following procedures:

1. Have sick cows and cows that are calving in a box stall on a soft floor with plenty of clean straw on top. Many dairy farmers do not have adequate box stalls available for sick and maternity cases. When a farmer is building a barn, he should put in adequate box stalls (at least one box stall to 20 cows). The floor of these box stalls

should be soft earth, sand over the cement, or a deep manure pack on the cement.

2. Treat the original disease condition as early as possible, especially milk fever cases. A farmer should try to recognize this disease early and get prompt attention to the cows involved. If these cases are treated early, they seldom become downer cows.

Hardware Disease (Traumatic Reticulitis)—Cattle are careless in their eating habits and it is very common for them to take in nails, bits of wire, etc., along with hay or grass. Such hardware drops to the floor of the reticulum (honeycomb) and may lie there for long periods without causing trouble. Frequently, however, a sharp object will pierce the stomach wall and admit infection. Affected cattle go off feed, produce less milk, and show signs of pain. The outcome is variable, with severe cases ending in death.

Early treatment with or without surgery will save most animals. Control should emphasize a cleanup of nails, etc., around the farm. Since it is very difficult to do this adequately, it has become common practice to give all breeding stock "rumen magnets." These straight, heavy magnets drop to the floor of the stomach, attract ferrous metals, and make any hardware much less likely to pierce the stomach wall. The magnets are comparatively inexpensive, cause little or no trouble in the cow's stomach, and are a proven method of reducing losses due to this disease.

Milk Fever—Milk fever is one of the most common diseases of dairy cows but it is also seen in beef cattle. Contrary to what the name suggests, the affected cows do not have a fever but have a low temperature. It occurs most frequently within the first 48 hours after calving but it can also occur before. The disease is characterized by a progressive muscular weakness. In early stages, the cow is weak and staggering, then as the disease progresses, she goes down, unable to get up and in later stages she will stretch out on her side, unable to lift her head. The disease is usually recognized in the middle stage where the cow cannot get up. She may have a kink in her neck or her head around on her flank. The disease has a sudden onset and the prompt treatment is essential because the earlier the cow is treated the better the results. If cows are not treated early, they may become downer cows, the condition described previously. Fortunately, the treatment of calcium salts intravenously is generally successful. An alternative treatment which may work well is to inflate the udder with air. This should be done with care, as there is danger of introducing mastitis germs. Control methods are being studied and some look promising, but they do have side effects and should be used under veterinary supervision. Vitamin D given 2 to 5 days prior to calving has been found beneficial. Another suggestion: A cow with a history of repeated attacks of milk fever could be given a bottle of calcium salts under the skin immediately after calving. A practical measure a farmer can follow involves incomplete milking for 2 to 3 days after calving unless the cow has mastitis. In this case, the affected quarters should be stripped out. Do not drench a cow with milk fever because its inability to swallow will probably result in the material reaching the lungs and causing pneumonia. Do not use antibiotic injections, because such medication is worthless.

Overeating Disease (Rumen Overload, Rumen Acidosis)—Cattle which gain access to more grain than they are accustomed to, either by accident or by a too-sudden introduction to self-feeders, are likely to become very ill. Mild cases will suffer only a setback and recover without treatment; severe cases may die despite treatment. The means of prevention are the restriction of cattle from areas where grain is stored, the gradual introduction of feeder cattle to self-feeds, and dilution of concentrate with roughage.

When overeating disease is suspected, veterinary advice should be sought at once.

DISEASES OF SWINE

An excellent publication, Swine Production—Diseases (Publ. 1442, Section 5), has recently been produced by the Canada Department of Agriculture, under the Federal-Provincial Co-operative Publishing Program. The text for this publication was prepared under the direction of the Saskatchewan Advisory Council on Animal Production, a council of the Saskatchewan Agricultural Services Co-ordinating Committee. Available from your agricultural representative.

DISEASES OF SHEEP

Nutritional Diseases

Whether sheep are raised on range or in confinement (dry lot) or combinations of these methods, the most common diseases in Saskatchewan are those due to improper nutrition. The diseases seen are usually a result of a deficiency or deficiencies in the diet, although a relative imbalance of dietary constituency (particularly calcium and phosphorus) may occur, leading to disease. It is strongly recommended that sheep owners take advantage of feed testing facilities available and follow recommendations for supplementation of the rations. It must be remembered that block salt licks are not very satisfactory for use with sheep as they are unable to obtain sufficient salt from them for their needs. Mineral and salt mixes may be fed free-choice in boxes but, certainly for fattening lambs, it is better to feed a compounded ration containing the necessary vitamins and minerals added, or have a pelleted supplement made to add to the feed.

Commonly seen in Saskatchewan are deficiencies or imbalances of calcium, phosphorus, and vitamin D. More of these problems will probably be seen as sheep are housed for longer periods and do not obtain the benefit of sunshine and supplementation from natural grazing. Signs vary from slow growth and high feed requirements through depraved appetites, unthriftiness, and development of a "knock-kneed" condition to tetany and cases of sudden death.

Care should be taken not to use untreated rock phosphate as a mineral supplement as it may contain an excess of fluorine, leading to fluoride poisoning.

Muscular dystrophy (white muscle disease) is another condition which occurs fairly frequently and is due to a deficiency of vitamin E and/or selenium. The disease is endemic in certain areas but may occur unexpectedly due to the purchase of grains or to particular crop-growing conditions, or where heavy grain rations are being used for the first time. The disease is usually seen in lambs between the ages of 1 and 8 weeks; the lambs present a hump-backed appearance, are reluctant to stand, and are stiff when made to move. Occasionally, this condition may be confused with a viral arthritis at this stage. Sudden deaths may occur. Stillbirths or death shortly after birth may also be seen. Prevention and treatment are by the use of vitamin E and selenium, either by mouth or as injections. The vitamin E level in commercial "Vitamin ADE" preparations is not high enough to be relied upon in those areas where the disease is prevalent. Selenium toxicity may also occur where too large doses are given.

Gross copper deficiency is not common, and the largest problem with this mineral is likely to be copper poisoning due to too high a level in a supplement. Care must be taken not to use commercial supplement manufactured for other species. Signs of toxicity are usually those of jaundice, although, rarely, other diseases may cause similar signs.

Vitamin A deficiency is generally seen in lambs in Saskatchewan. Night blindness is usually the first sign and this may progress to total irreversible blindness. Other signs are weakness, emaciation, inco-ordination, loss of appetite, and occasionally diarrhea. In ewes on a deficient diet, signs are often not seen for one or two lambing seasons after which stillbirths and abortions may occur.

Iodine deficiency is still sometimes seen and usually where the only mineral supplement is in the form of salt blocks (whether or not they contain iodized salt). In adults signs of disease are not readily apparent, except for low milk yield, poor conception rates, and poor wool growth. An enlarged thyroid gland may be visible as a swelling in the

neck. The usual results are the birth of dead lambs, lambs that are weak and die shortly after birth, or premature births. Lambs born with an enlarged thyroid gland rarely survive.

Another condition associated with feeding is that of urinary calculi. Although not a major disease of sheep in Saskatchewan, it can be a cause of the loss of a few lambs year after year on the same farm. The disease is associated usually with a high content of certain minerals in the water supply and in the feed. "Stones" are formed in the urine and may occur in the kidney and/or the bladder. When they occur in the kidney few definite signs may be seen before death. But the animal may appear to be a "poor doer." Most commonly calculi become lodged in the urethra. The disease is most commonly seen in males (entire or castrated) in the penis, and the animal is unable to pass urine. The animal will strain and this is often thought to be due to constipation. Treatment is usually surgical and is usually too expensive unless the animal is very valuable. Even in these cases, a "cure" may only be obtained at the sacrifice of the animal's reproductive capabilities. Urinary calculi may be prevented. The method to be adopted will depend on analysis of the calculi and of the feed and water supply.

Marginal deficits of any food element may occur and while they produce no definite signs there may be poor growth rates and the animal's resistance to disease may be lowered.

Conditions Affecting the Rumen

Rumen overload, or acidosis, is more commonly seen in feeder lambs, although it may occur in mature sheep also. The condition occurs when sheep gain sudden access to concentrate rations, particularly where barley is the main constituent. Several animals may be found dead or recumbent, with others staggering as though drunk. Animals may appear bloated. If death does not occur rapidly, scouring may be seen. A similar clinical picture may sometimes be seen with enterotoxemia, so where deaths occur a post-mortem examination is essential. Treatment is with alkalinizing agents, such as magnesium hydroxide, by mouth. Where valuable animals are involved the administration of parental fluids may assist. All feeding changes should be gradual.

Bloat more commonly occurs when sheep are suddenly turned onto a bush pasture, particularly a clover pasture, although cases are sometimes encountered when sheep feed on concentrate rations and alfalfa hay. This type of bloat is usually of the frothy type and the administration of mineral oil or cooking oils (such as sunflower seed oil) together with a surface-acting agent such as "Dioctol" is recommended. The odd case of a free-gas bloat may be relieved by passage of a stomach tube. Sheep should be given a feed of dry hay before being released on bush pastures.

Parasite Control

a. **External Parasites**—These are controlled by the application of insecticides, which is best done when the wool is short. Insecticide application is usually delayed until about 10 days after shearing, when any wounds should have healed. Commercial preparations of various insecticides are available and may be applied by dipping, dusting, or spraying, although dipping is probably the most satisfactory. The dip should be kept agitated and the animal held in it for 1 minute. The head should be dipped last by placing a hand over the muzzle and keeping the head inverted for 1 second. This will ensure control of keds and lice. These insecticides may be toxic and should only be used according to the manufacturers' instructions, and care must be taken in their disposal. There are many causes of loss of wool in sheep, including sheep scab, which is a reportable disease, mycotic dermatitis, and ringworm, which is rare. If in any doubt as to the cause, laboratory examinations of portions of the affected fleece and of skin scrapings should be carried out.

b. **Internal Parasites**—Tapeworms are not usually a severe problem in sheep. Liver flukes are found in certain areas of Canada but are not a problem in Saskatchewan.

When dealing with internal parasites we are generally referring to the roundworms found in the intestines and the lungs. The long, cold winters aid in clearing the pastures of infestation, although overwintering of eggs may occur with certain intestinal worms and there will be a carry-over in infected animals. It is recommended that a broad-spectrum anthelmintic (such as thibenzole or tetramasol) be administered twice yearly: once in the spring before putting onto pasture and again in the fall when putting into the day lot for the winter. Flocks going into confinement rearing should be wormed on entry and then fecal samples checked at intervals to ensure that there is no buildup of infection. With confinement rearing and the proper placing of feed bunks, it should be possible to eliminate parasitism as a problem.

Despite the routine use of anthelmintics, a buildup of parasites may occur on the pastures and this will be most noticeable in the young lambs. Lambs born in the day lot will be particularly susceptible to parasite infestations on pasture.

c. **Coccidiosis**—This disease is most serious in feedlot lambs. Outbreaks usually occur 2 to 3 weeks after the lambs enter the feedlot, and it is believed that the change to a rich diet is the major factor involved.

The signs first noted are a softening of the feces, which then become liquid and usually contain blood. The hindquarters of the lambs are stained with feces and, where straining is a sign, with blood. Animals are depressed, off feed, and rapidly lose weight. A large percentage of the lambs are usually affected.

Diagnosis is based on the signs, on post-mortem examinations, and on laboratory examination of the feces.

Treatment is probably not very effective in shortening the course of the disease, although claims have been made for nitrofurazone and some of the sulfa drugs.

Care should be taken to change lambs onto concentrate rations gradually. Feed and water troughs should be raised. The provision of clean, dry bedding will also cut down the spread of the disease.

Reproductive Diseases

There are many causes of abortion in ewes and although they have so far not been of major importance in Saskatchewan, the danger of the introduction of such diseases is very real. Vibrionic abortion has recently been diagnosed in Saskatchewan sheep and has given rise to serious outbreaks in some flocks. The Vibrio organism which causes abortion in sheep cannot be transmitted to cattle. In sheep, vibrionic abortion is spread by ingestion and the fetus is expelled in late pregnancy.

The causes of abortion are many and some are transmissible to man; therefore, whenever an abortion occurs it is recommended that the aborted fetus, together with the afterbirth, be sent for laboratory examination.

Rams suffer from various infections of the testicles, penis, and sheath. Any affected animals should be isolated and not used for breeding. Veterinary advice should be sought.

Infectious Diseases of Lambs

Colibacillosis—This is not common when ewes lamb on pasture but is common in dry lots and lambing sheds. The disease is usually seen in lambs under 2 days old. Diarrhea develops and the feces are soft and yellow. Later they become fluid and may be blood stained. Without treatment, death usually occurs in 24 to 36 hours. Some lambs die rapidly, without any signs of scouring. Joint-ill and meningitis in young or older lambs may also occur.

Colibacillosis must be differentiated from other scouring diseases, e.g., enterotoxemia (overeating)—some lambs may develop diarrhea. Salmonellosis, coccidiosis, and intestinal parasites do not commonly occur in animals this young.

Treatment includes sulphonamids, nitrofurans, antibiotics, fluid therapy, and good nursing; sensitivity testing in the laboratory to determine which antibiotic may be effective.

Prevention and control measures include the following practices: lambs should receive colostrum as early after birth as possible—certainly within 12 hours; sanitation; lambing pens should be designed to hold small numbers and be dry, roomy, well ventilated, and free of draughts; introduction of animals from other flocks should be avoided when possible.

Salmonellosis—This disease is often very similar to colibacillosis, although it may also affect feeder lambs. The scours are more generally of a greener color and may contain blood. Bacteriological cultures are necessary to differentiate the two diseases. Carrier animals may occur with this condition, and as the disease is transmissible to man, correct diagnosis is essential. Treatment is similar.

Septicemia (Navel Infection)—The navel is a common site for the entrance of infection. Depending on the organism involved, different signs will be seen. Very often there is acute illness and rapid death due to a septicemia. There may be a meningitis (inflammation of the brain); the signs of meningitis vary depending on which area of the brain is affected. There is usually excitement, followed by convulsions, coma, and death. Arthritis is a common result of navel infection and may appear as the classical joint-ill where the joints are swollen and contain pus. In the more chronic form the most obvious sign may be lameness in one or more legs with little swelling of the joints.

Treatment with antibiotics is usually effective.

Preventive measures include cleanliness at lambing time and dipping of navels in tincture of iodine (5 to 7 percent) shortly after birth.

Docking and Castration Infections—Depending on the organisms involved, the signs are very often similar to those following navel infection. The condition may remain more localized with abscess formation.

Tetanus may follow docking and/or castration, regardless of the method (knife, Burdizzo, or rubber bands) used, if the procedure is not carried out clearly. Lambs appear stiff, go into spasms, and adopt a "saw-horse" attitude. Treatment is not very effective when the signs are well advanced. In some areas vaccination may be necessary.

Enterotoxemia (Pulpy Kidney)—Although this disease may be seen in sheep of all ages, it is most common in lambs.

Prevention depends on management and vaccination. Changes to high-concentrate rations (or lush pastures) should be made gradually, parasites should be controlled, and regular feeding is essential. With feeder lambs it may be advantageous to leave them on a self-feeder once they are on full ration.

Vaccination programs adopted will depend on the management practices of the individual farmer and the disease picture.

Whatever the overall program, it is essential that all lambs be vaccinated prior to entry to the feedlot or as soon after as possible. Protection of the very young lambs may depend on protection by maternal antibodies in the colostrum of a vaccinated mother. Protection can be provided by the administration of antitoxin to the lamb, or vaccination with the new 2-milliliter-dose toxorets. Veterinary advice should be obtained for the best procedure on each farm.

Pneumonia—This is probably the most common disease of sheep, affecting sheep of any age. The bacteria and viruses involved are many but the biggest factor is stress associated with such events as weaning, transportation, shearing, and weather. The design and construction of housing is probably the biggest problem so far as lambs are concerned. Ventilation should be adequate and freedom from draughts is essential. A design that permits areas where the air is stale and humid causes more problems than low temperatures. Antibiotics are used to treat individual animals and may be used on a flock basis in the face of large outbreaks. Good housing and good management to avoid stress are the essentials in prevention.

Foot Rot—Usually associated with warm, wet conditions. More common in rapidly growing lambs and lactating ewes. Lambs may be infected in two, three, or even four feet. Adults are usually affected in one or two feet only. Highest incidence is at 2 to 4 weeks of age. Males are more severely affected than females.

Lameness is most common in the hind legs. There is a moist, foul-smelling area between the claws which may spread under the horn. This leads to separation of the horn and overgrowth and deformity of the foot. There is no pus formation and no swelling above the hoof.

Treatment and Control: The foot **must** be pared properly if a cure is to be obtained. Secateurs (hoof shears) are used to cut away the large pieces of excess horn and then the foot is pared with a fine knife. The blade should be sharp and not exceed the length of the operator's thumb. The cutting edge should be directed away from the sensitive tissues, with the hand resting firmly against the hoof. Care should be taken not to injure the exposed tissue. Injury delays healing and the blood obscures the site, making it difficult to distinguish between healthy and infected tissue. The carefully pared foot may be sprayed with a variety of products in aerosol form (chloramphenicol, dichlorophen, cetrimide, etc.) or the animal may be walked through a footbath of 10 percent formalin. Parental treatment with a combination of penicillin and streptomycin may also be used but is more expensive.

To eradicate the disease the feet of **every** animal in the flock must be examined. Affected animals are separated from the healthy ones and treated as outlined above. All sheep in the flock are walked through a formalin footbath. One week later all sheep are again examined and the whole flock put through the footbath. The third week, only previously infected animals are re-examined but the whole flock again receives the footbath treatment. Consideration should be given to disposing of animals which have not responded to treatment. The whole flock should be re-examined 6 weeks later.

Care must be taken to avoid the re-introduction of the disease with newly purchased animals. The carrier animal may exist and if an animal is found which it repeatedly affected (here records help), it should be culled.

Diseases of the Ewe Associated with Lambing

Mastitis in Ewes—Mastitis has often been said to be the most important disease of range ewes and is also important in confined flocks. While the incidence is generally low, explosive outbreaks involving up to 50 percent of the ewe flock may occur. Several different species of bacteria have been isolated from clinical cases, one of which (Pasteurella haemolytica) is often found in cases of pneumonia in lambs. The fact that the causal organisms are so common makes total eradication extremely difficult.

The disease is usually sudden in onset: there is high fever (105°-107° F) and the ewe goes off feed and lags behind the flock. Infection is usually in one side of the udder only and the gland is hot, swollen, and painful. The swelling and pain cause the animal to carry the leg away from the udder, and she appears lame. The milk first contains small flakes and rapidly becomes thick and full of curds. Occasionally, the secretions are very watery and bloody. In some cases the udder becomes gangrenous and portions may slough off. Without treatment, up to half the affected animals may die. Death usually occurs in 3 to 7 days. In those which survive abscess formation usually occurs in the udder and may be so severe that the gland may just be a bag of pus. In some cases (depending on the different organisms involved) the affected half of the udder may become hard and fibrotic (full of scar tissue).

To have any degree of success, treatment must be started early in the course of the disease (within 12 hours). Various antibiotics may be used and should be given in high doses. Intramammary preparations of the antibiotics should be used as supportive treatment after milking out the quarter as completely as possible. Treatment should be continued for 3 days.

With early treatment many animals may be returned to production and be able to rear their lambs to weaning. Unfortunately, it is extremely difficult, and uncommon, to produce a complete bacteriological cure and organisms may survive in the udder. The ewe is therefore liable to have a repeat attack at the next lambing season and is a potential source of infection to the rest of the flock. All ewes that become infected should therefore be marked and culled as soon as the lamb is weaned.

Various attempts have been made to produce vaccines against mastitis in sheep but so far without any practical success. Neither does it appear possible to eradicate the disease entirely from a flock by management practices. However, the incidence may generally be kept low by careful shepherding of the flock, early isolation and treatment of affected animals, and by rigid culling.

Pregnancy Toxemia (Twin-Lamb Disease)—As the name indicates, this disease afflicts in-lamb ewes. It occurs late in pregnancy. Ewes carrying twins or triplets are most commonly affected. Affected ewes able to lamb will usually recover spontaneously but, generally, the disease leads to death of the ewe before the birth of her offspring. At first, affected animals lag behind the flock, become dull, urinate frequently, and grind their teeth. Nervous signs develop and the ewe may be stupid or excitable and appear blind. Trembling after exercise, with twitching of the lips and face muscles, is characteristic.

An adequate diet throughout pregnancy, particularly during the final stages, is essential. A pregnant ewe will suffer more from an inadequate diet in the last 2 months of gestation than in the early stages.

It is very important that ewes in advanced pregnancy do not miss a feed for any reason (e.g., bad weather).

Treatment should be started early in the course of the disease. Four ounces of propylene glycol in warm water every 12 to 26 hours may be sufficient. If an early response to treatment is not obtained veterinary advice should be sought.

General Advice

Good management practices (the correct handling of animals, good nutrition, good housing, and the avoidance of stress) will go far to reduce disease losses in a sheep enterprise. Good records are essential. It is impossible to list here all the conditions which may affect sheep in Saskatchewan or indeed to go into great detail of those conditions discussed. Whenever problems arise, early consultation with the veterinarians and veterinary services listed at the end of this section could do much to minimize losses.

DIAGNOSIS OF POULTRY DISEASE

Before You Treat, Obtain a Diagnosis from:

Department of Veterinary Pathology, Western College of Veterinary Medicine, Saskatoon; a local veterinarian; Veterinary Diagnostic Laboratory, Regina.

You Require a Diagnosis When:

Several birds die suddenly; birds lose weight, drop in production, show poor growth; birds are droopy, listless; birds exhibit blindness, lameness, abnormal posture, or movement; birds cough, sneeze, shake heads; birds have loose or bloody droppings.

What to Submit for Diagnosis:

Four to five birds showing typical signs; preferably two to three fresh dead birds with one or two live sick birds; if birds are coughing, sneezing, or having difficulty breathing, one must send several live birds; arrangements should be made so birds are in transit as short a time as possible or they may be useless.

Information Required for Diagnosis:

Name: .....

Address: .....

..... Telephone No.: .....

No. in flock ..... No. sick ..... No. dead .....

Sick birds died ..... days after start of illness. .....

..... number of birds have died over a period of .....

days or weeks. Vaccinated for .....

at ..... days or weeks of age. Illness started when birds

were ..... days/weeks/months old. Age of birds now

..... What is being fed now (in detail) .....

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.....

.....

Type of housing and litter condition .....

.....

Have the birds been given any treatment? .....

If so, how long ago? ..... Are they on treatment

now? ..... If so, what drug is being used? .....

..... How is it being administered? .....

..... What abnormalities have you observed, e.g., drop in production, loss of weight, poor growth, diarrhea, lameness, abnormal posture or movement (describe), blindness, cloudy eyes, poor feathering, droopy, listless, sneezing, difficult breathing? .....

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Packaging for Express, Mail, and Bus:

Fresh, Dead Birds—Roll birds in newspaper and put in cardboard box. Tie box with cord. In warm weather, place picnic-type coolant pack next to bird.

Live, Sick Birds—Wood or strong cardboard crate, wood shavings or straw on bottom of crate. Some air holes. Tie cardboard box with cord.

How to Ship: —**Live or Dead Birds**—Submit birds yourself or by messenger; rail express.

Dead Birds (Only)—Truck express; bus express; parcel post (boxes must be wrapped as well as tied).

Send Specimens to—The nearest laboratory: Veterinary Laboratory, c/o Provincial Laboratories, 901 Motherwell Building, Regina, Saskatchewan, phone: 522-8255; Depart-

ment of Veterinary Pathology, Western College of Veterinary Medicine, University of Saskatchewan, Saskatoon, Saskatchewan, phone: 343-5671.

VETERINARIAN AND VETERINARY SERVICES AVAILABLE IN SASKATCHEWAN

Assiniboia—Moneo, D. S.; **Balcarres**—Wilson G. A.; **Biggar**—Campbell, D. G.; **Canora**—Robinson, M. F.; **Carlyle**—Belosevic, S.; **Central Butte**—Muri, P.; **Climax**—Sherven, G.; **Davidson**—Zeman, F. J.; **Dinsmore**—Storry, W. J.; **Earl Grey**—Kessler, J. A.; **Estevan**—Harvey, J. A., Mikroulis, N.; **Grenfell**—Stewart, J. E.; **Humboldt**—Milin, G.; **Kamsack**—Podhaniuk T.; **Kelvington**—Hashimoto, J.; **Kindersley**—Barth, A. D., Richardson, G. F.; **Kipling**—Kessler, G. A.; **Langenburg**—Wyand, D. W.; **Leader**—McCall, E. J.; **Lloydminster**—Ellis, L. B., Hepworth, L. H., Schacham, P., Weir, G. K.; **Maple Creek**—Brewitt, J. M., Hoffer, M. A.; **Meadow Lake**—Bacon, H. A.; **Melfort**—Just, K. E., Wurtz, B. M.; **Melville**—Vandane, J. E.; **Moose Jaw**—Crabb, W. B., MacDonald, D. F., Perry, A. W., Starrak, E. S.; **Moosomin**—Johnson, H. D.; **Nipawin**—Pratt, D. A.; **North Battleford**—McCallum, A. W., McIsaac, J. C.; **Ogema**—Struthers, H. C.; **Outlook**—Ormiston, H. E., Ormiston, T. T.; **Oxbow**—McLean, R. R.; **Preeceville**—Krauss, R. J.; **Prince Albert**—Chapuis, B., Just, H. H.; **Redvers**—Von Staden, W.; **Regina**—Clarke, R. R., Dorosz, E. R., Dowdeswell, O. G., Fawcett, C. D., Hunter, H. J., King, G. H., Neufeld, E. J., Waechter, R. A.; **Rosthern**—Clark, E. G., McLean, S. J.; **Saskatoon**—Gibbs, B. W., Hills, K., Hurov, L. I., Seer, G., Western College of Veterinary Medicine; **Shaunavon**—Cadieux, K. B., Dupmeier, T. K.; **Shellbrook**—Rothwell B. W. R.; **Spiritwood**—Bone, J. W.; **Stoughton**—Vaitkus, J.; **Swift Current**—Hope, R. M., Marshall, C. M.; **Tisdale**—Evenson, R. V. J.; **Unity**—Rempel, P. D., Weeks, F. J.; **Wakaw**—Edwards, P. V.; **Watrous**—Kessler, B. G.; **Wawota**—Perry, R. W.; **Weyburn**—Kononoff, W. P., Nicholson, W. R.; **Wynyard**—Newell, R. R.; **Yorkton**—Konkin, P. J.

The Provincial Veterinary Division

The headquarters of the Veterinary Services Division is in Regina, located in a new laboratory and office building east of the bypass on grounds adjoining the Canada Department of Agriculture Research Station. Diagnosis of disease and disease control is an important function of the Division, and the Laboratory is available to veterinarians and livestock owners for this purpose. The Division administers various disease control measures and policies such as those for mastitis, rabies, swine herd health, meat inspection, and calfhood vaccination. It also administers the Veterinary Service District Plan, covering payment of grants to organized districts and co-operates with the Government of Canada Health of Animals Branch, in the servicing of federal disease control and eradication programs.

Health of Animals Branch
Canada Department of Agriculture

The Health of Animals Branch administers legislation designed to prevent the introduction or spread of serious diseases in Canada, and to assure the health of livestock and the wholesomeness of livestock products for export. Services provided for in the Animal Contagious Diseases Act, Canada Meat Inspection Act, and Humane Slaughter of Food Animals Act are carried out by the Branch's three divisions: Contagious Diseases, Meat Inspection, and Animal Pathology.

The Health of Animals Branch in Saskatchewan has its headquarters at 828 Motherwell Building, Regina, which is the office of the District Veterinarian. Field offices are located at Moose Jaw, Carlyle, Assiniboia, Swift Current, Shaunavon, Maple Creek, Weyburn, Yorkton, Humboldt, Prince Albert, Saskatoon, North Battleford, Lloydminster, and Kindersley. Regular import-export inspection facilities are available at North Portal. Services are available, by appointment, at Regway, Monchy, East Poplar, North Gate, and Willow Creek.

The three divisions of the Health of Animals Branch are represented in Saskatchewan:

The Contagious Diseases Division (Head Office: 828 Motherwell Building, Regina) supervises control and eradication of serious infectious and contagious diseases of livestock and poultry. This division also oversees inspection and certification of livestock for export and import.

The Meat Inspection Division conducts ante- and post-mortem inspection of animals slaughtered at federally registered meat-packing plants, as well as certification of same for provincial and export trade.

The Animal Pathology Division, located in the J. S. Fulton Building, University of Saskatchewan, Saskatoon campus, provides laboratory support for diagnosis of diseases of livestock and wildlife, and also conducts research in livestock diseases.

Western College of Veterinary Medicine

The College was established in 1964 on the Saskatoon campus of the University of Saskatchewan. It is the only Canadian veterinary college west of Ontario.

Classes of approximately 30 veterinarians have graduated each year since 1969. Commencing in 1973, the number graduating each year will increase to about 60. Graduate programs at the Ph.D., Master's, and Diploma levels are also offered.

In addition to the formal teaching program, educational courses for graduate veterinarians and livestock owners are presented at various times throughout the year at many locations in the province.

The College conducts an extensive program of research into diseases of livestock, poultry, wildlife, and environmental problems.

The diagnostic services at the College are specialized. Therefore, livestock owners seeking help are advised to work through their local veterinarian. Whenever possible, the College provides consultation and diagnostic services for difficult and obscure animal diseases.

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SERVICES

SASKATCHEWAN DEPARTMENT OF AGRICULTURE

Administration Building, Regina

The Agricultural Extension Branch

The Agricultural Extension Branch is the main extension agency of the Saskatchewan Department of Agriculture and has as its primary objective that of maintaining and increasing the overall efficiency of agricultural production. To that end it provides a basic extension program designed to:

1. Ensure that the most modern farming techniques and the latest research findings are made available to farmers.
2. Provide leadership and general guidance in agricultural adjustment programs needed to bring about necessary social and economic progress.
3. Co-ordinate and administer field programs and policies sponsored by other branches for the purpose of encouraging desirable adjustments in agricultural production and to cope with emergency situations.

The Branch endeavours to maintain close co-operation with other branches of the Department as well as the University of Saskatchewan and the Canada Department of Agriculture in the three-way co-ordination of agencies known as the co-operative extension program.

The field staff consists of 41 district agricultural representatives. Agricultural committees have been appointed by most rural municipal councils. Each committee, with the advice and counsel of the agricultural representative, plans an agricultural improvement program for its municipality.

The district board, comprised of representatives from each rural municipality in the district, promotes an improvement program on a district basis.

For further information please contact your agricultural representative.

Agricultural Extension Branch

(List of Professional Staff)

	Name	Address	Phone Office	Phone Home
Director	D. H. Grant	Government Administration Building, Regina	525-6111	586-5092
Assistant Director	M. Brounstein	Government Administration Building, Regina	525-6111	586-6848
Supervisor, Agricultural Manpower Services	C. C. Cooke	Government Administration Building, Regina	525-6111	584-0927
Administrative Officer	H. P. Charlton	Government Administration Building, Regina	525-6111	522-0455
Agricultural Communications Division				
Supervisor	R. S. Reid	Government Administration Building, Regina	525-6111	584-2854
Agricultural Communications Representative	A. D. Lozeron	Government Administration Building, Regina	525-6111	586-3007
Agricultural Communications Representative	F. G. Stroppa	Government Administration Building, Regina	525-6111	586-7886
Audio-Visual Technician	D. L. Giles	Government Administration Building, Regina	525-6111	523-4482
Regional Extension Co-ordinators				
	R. E. Middleton	2nd Floor, Bus Depot, North Battleford	445-3805	445-8559
	M. W. Oxman	Box 1477, Melfort	752-2728	752-3329
Agricultural Representatives				
District No.				
1	P. M. Gerwing	1132 - 4th Street, Estevan	634-2535	634-6005
2	W. D. McLaren	Box 250, Assiniboia	642-4624	642-5167
3	R. J. Christenson	Box 250, Assiniboia	642-4624	642-4673
4	A. E. Mulhern	Box 429, Eastend	295-3563	295-3587
5	J. E. Smith	Box 239, Moosomin	435-3177	435-2627
6	W. V. Beaulieu	Box 399, Indian Head	695-3505	695-3582
7	P. H. England	13 - 1st Street NE, Weyburn	842-2832	842-4430
8	J. O. Hanson	60 Fairford Street W, Moose Jaw	692-4521	692-9165
9	L. I. Peterson	No. 1 Plaza Shopping Centre, Swift Current	773-6421	773-4154
10	J. I. Clark	Box 938, Maple Creek	667-2464	667-2361
11	J. H. Pratt	Box 397, Leader	628-3661	
12	P. W. Petersen	20 - 3rd Avenue S., Yorkton	783-4193	783-7671
13	C. G. Casswell	Box 10, Melville	728-2100	728-5756
14	G. E. Parker	Government Administration Building, Regina	525-6111	586-6196
15	J. W. Kunkel	Box 693, Davidson	567-2806	567-2005
16	A. E. W. Colton	Box 9, Outlook	867-8128	867-8750
17	S. S. Solar	Box 506, Kindersley	463-2231	463-3123
18	L. Koturbash	Box 219, Kamsack	542-2734	542-2407
19	O. Mysak	Box 658, Canora	563-5313	563-5297
20	S. D. Adam	Box 580, Wynyard	554-2341	554-2357
21	N. L. White	Box 159, Watson	287-3372	287-3631
22	P. S. Saum	Canada Agric. Research Station, University Campus, Saskatoon	343-9506	373-1760
23	H. B. Nickel	Box 1145, Biggar	948-2666	948-3661
24	A. W. Sereda	Box 678, Kerrobert	834-2323	834-2268
25	J. M. Holm	Box 609, Hudson Bay	865-2581	865-3129
26	H. N. Lang	Box 249, Tisdale	873-2524	873-2868
27	E. J. Bendig	Box 1477, Melfort	752-2728	
28	L. J. Darwent	Box 70, Wakaw	233-4312	233-5189
29	F. D. Miller	Box 538, Rosthern	232-5566	232-4248
30	H. R. Amundson	Box 240, Wilkie	843-2231	843-2217
31	B. J. Strilchuk	Box 2166, Nipawin	862-4413	862-4394
32	D. M. England	Land Titles Building, Prince Albert	764-5261	764-2624
33	R. A. Evans	Box 86, Shellbrook	747-2477	747-2274
34	B. K. McDonald	2nd Floor, Bus Depot, North Battleford	445-2282	445-4866
35	R. J. Brassard	4816 - 49th Avenue, Lloydminster Alberta Code 403	825-4632	825-2547
36	P. P. Shukin	Box 369, Meadow Lake	236-5355	236-6146
37 (Far North)	J. D. Neilson	Land Titles Building, Prince Albert	764-5261	763-6213
38	R. D. Roney	Box 207, Turtleford	845-2131	845-2004
39	H. R. Kingdon	Box 579, Fort Qu'Appelle	332-5335	332-5918
40	W. O. Lee	Box 640, Rosetown	882-2041	882-3516
Agricultural Representative Special Projects				
(Indian and Metis)	M. MacKay	Land Titles Building, Prince Albert	764-5261	763-2405
Assistant Agricultural Representatives				
8	D. M. Winsor	60 Fairford Street W, Moose Jaw	692-4521	692-9831
29	F. P. Howell	Box 538, Rosthern	232-5566	232-5415
9	G. L. McLean	No. 1 Plaza Shopping Centre, Swift Current	773-6421	
Training Farm Manager	B. E. Joinson	Cumberland House	66	76

Other Branches of S.D.A.

Administration
Overall administration of the Department under the Deputy Minister covers policies, programs, personnel, budgeting, accounting, grants, and ARDA Administration.

Conservation and Development Branch
Provides engineering services for irrigation, drainage and flood control, and special water development projects on request from local organizations and other departments and agencies; administers related acts, policies, and programs. The Branch is responsible for the design and construction of the works for the South Saskatchewan River Irrigation Project and does the physical development work on provincial community pastures.

Economics and Statistics Branch
Conducts agricultural economic research, collects agricultural statistics, and provides farm business management extension services. Research activities include the preparation of outlook and market information, and economic studies of agricultural programs and policies. A crop reporting service is also provided. Farm business management extension services include courses, individual farmer consulting, the preparation and distribution of farm business information, and a farm accounting analysis service. Regional farm management specialists are located at Swift Current, North Battleford, Melfort, and Regina.

Family Farm Improvement Branch (FFIB)
Provides professional and technical advice on farm and farmstead mechanization and modernization, including water source development, water and sewage systems for farms and small communities, structures, equipment, and materials handling systems. The Branch sells outdoor water and sewage materials, administers the Agricultural Implements Act and other policies and programs related to agricultural engineering extension work. FFIB organizes and sponsors annual MEXABITIONS in Regina and Saskatoon.

Lands Branch
Administers 8.5 million acres of provincial lands through lease and sale agreements, operates provincial community pastures, acquires marginal land for incorporation into community pastures or forage projects, and purchases land offered for sale within the South Saskatchewan River Irrigation Project. Programs of having clearing and breaking done and paying for it on suitable provincial land come under the jurisdiction of the Branch . Administers Indian-Metis training farms.

Production and Marketing Branch
Provides the services of livestock production field crops, and animal diseases specialists who consult with farmers on production plans and methods of overcoming problems of production and marketing. These specialists summarize the latest scientific findings in agriculture and make this information available to farmers through agricultural representatives, bulletins, meetings with farm groups, the news media, and in consultation with individual farmers. A veterinary diagnostic laboratory is provided to assist in animal disease diagnosis. The Branch has many regulatory functions such as: Brand inspection, licensing and bonding livestock dealers, licensing seed dealers, etc., including the administration of a variety of regulations controlling the facilities for marketing various agricultural products and standards of quality for these products.
Regional livestock specialists are located in the Department of Agriculture Extension Offices at North Battleford, Melfort, Yorkton, and Swift Current.

Saskatchewan Crop Insurance Board
The Board administers the Saskatchewan Crop Insurance Program under the direction of the Minister of Agriculture. The objective of the Board is to make available to farmers, a comprehensive all-risk crop insurance plan on a voluntary basis.

Milk Control Board
The Board is independent and functions separately from the Department. It administers the Milk Control Act which determines the price of fluid milk sold in cities.

EXTENSION DIVISION

UNIVERSITY OF SASKATCHEWAN, SASKATOON

Non-Degree Programs

The Extension Division offers a variety of non-degree programs. Its primary objective is to provide continuing education to the volunteer learner who, through personal interest or the demands of vocation, requires the kind of knowledge available through university sources.
Educational demands are becoming increasingly diversified, and the University's extension activity is an attempt to meet the demands for knowledge and competence from those who would not normally register in regular degree programs.
The Division's principal interest is the adult whose day-to-day responsibilities require imaginative and creative leadership. Special emphasis is placed on providing instruction to those who have teaching or consulting responsibilities in programs of continuing education, i.e., extension-type programs in the community. For example, the organizational leader or the instructor of evening classes requires help in educational program planning and informal teaching techniques, or the agricultural, home economics, or engineering specialist may need updating on new research findings in his or her field.

Note: Information on any aspect of the Extension Division's program may be obtained as indicated in the outline of the Division's three departments below, or by writing to the Extension Division, Kirk Hall, University of Saskatchewan, Saskatoon.

Program Development Department
This Department of the Extension Divison is responsible for designing and conducting educational programs. It can normally provide programs that extend any subject matter offered through a department, college, or professional school on the campus. Specialists from within the departments, colleges, and professional schools on campus and from other universities are involved as instructors in extension activities. In some cases, specialists from the community at large are invited to provide instruction.
Those wishing to develop educational programs should contact the Head, Program Development Department. Ideas or requests for such programs are developed by Extension Division staff groups, normally in collaboration with a requesting organization or agency and with faculty specialists. The following outline will indicate the major programs which can be made available to the Saskatchewan community, through a variety of methods; weekly classes, short courses, institutes, seminars, conferences, publications, and television and radio programs.

1. Social and Economic Development Program—The objectives of this program are to have people with leadership responsibilities in community development increase their competence to perform their tasks. To this end the program offers continuing learning experiences for a variety of clientele groups. Included are professional urban planners, para-professionals who perform community planning functions, citizen planning groups, as well as the broad range of professionals and para-professional personnel who effect community development decisions through their work in civil service and the private sector.
Courses are developed with a variety of focus and length depending on clientele needs. Community analysis, needs identification, organization, communication, planning, and evaluation, are examples of subject matter that can be covered.
In addition to courses, university faculty interested in community development are available for consultation with agencies. organizations, or representatives of communities interested in community development.

2. Agricultural Science Program—In co-operation with the College of Agriculture, the Western College of Veterinary Medicine, the Canada and Saskatchewan Departments of Agriculture, and farm organizations and agencies, the Extension Division offers annually a wide variety of educational events in agriculture.
University Farm and Home Week is an annual event occurring in the second week of January each year. featuring lectures and discussions on topics of both current and long-term interest. Other central projects include short courses on livestock, field crops, marketing, soils, machinery, horticulture, agricultural economics, and farm business planning.
Other events include Stockman's Day and the Agricultural Economics Department's Farm Forum.
Professional development courses for agrologists and veterinarians are offered annually.
Each year, university agricultural specialists instruct at about fifteen 3- to 4-day regional courses throughout the province. Special demonstration programs on crops and machinery are conducted.
The Guide to Farm Practice in Saskatchewan can be obtained free. A periodical entitled *Saskatchewan Farm Science* is available to individuals on a subscription basis at $1.00 for 2 years. A bibliography of publications listing nearly 100 agricultural pamphlets is available on request.

3. Business and Industry Program—The Extension Division offers, in co-operation with the Colleges of Commerce and Engineering, and other related sources of subject matter on the campus, a number of educational projects of interest to personnel in business and industry; managers, accountants, personnel managers, owners of small businesses, and professionals such as engineers. Courses and seminars are available on such topics as management, accounting, human relations, computer programming, production control, work study methods, electronics, statistical analysis, and marketing.

4. Home and Family Program—The objective of the program is to encourage families to gain wider knowledge, modern skills, and to develop an awareness and appreciation of roles and attitudes resulting in more satisfactory living as family members, and effectiveness as individuals in the community.
Learning experiences are available in a wide variety of topics related to the home and its family members. These experiences are based on needs expressed by family members planned through their association with community organizations or through informal groups with common interests.
Training and updating opportunities are offered for home economists and interested individuals in areas of study related to homes and families. Television and radio programs, newspaper articles, and a bi-monthly publication, *Homes and Families*, bring into homes knowledge which assists families in today's changing society.

5. Intercultural Relations Program—Three main functions concern the Intercultural Relations Program — programming, production of publications, and liaison. In programming, non-credit courses are offered in Oral French, Oral Cree, Indian History and Culture, and Canadian Pre-History and Archaeology. In addition, various citizens' programs intended to improve cross-cultural understanding and appreciation are held throughout the year. In publications, Volume of *Saskatchewan Indian History* was published in 1971 and work is continuing on the follow-up volumes. In order to help cultural groups in the province meet their various programming and organizational needs, the Intercultural Relations Program maintains a close liaison with these groups of people.

6. Leadership Development Program—The Extension Division offers educational experiences for leaders associated with organizations, agencies, and communities. Such experiences may be derived through courses, consultation, or publication. Subject-matter areas offered include teaching of adults, group work, human relations (including sensitivity training), communications, program planning, conduct of meetings, and other aspects of leadership.

7. Public Affairs Program—This program seeks to increase people's awareness, knowledge, and understanding of selected public issues. The Division's program has offered weekly classes and conferences which have concentrated upon international affairs; or upon the political systems of Canada and the U.S.A. Plans for the future are intended to achieve a balance of offerings between provincial, national, and external issues; and to offer "packaged" educational materials in a form which will permit their wider use by voluntary groups throughout the several regions of Saskatchewan.

Program Instruction Department
The Program Instruction Department of the Extension Division performs several functions designed to facilitate the productivity and quality of the Division's program.
1. Maintain continuing contact with regions, organizations, and agencies in the province for the purpose of understanding needs on which University Extension programs should focus.
2. Maintain continuing contact with subject-matter colleges, schools, and departments within the university community for the purpose of identifying appropriate resource staff for University Extension programs.
3. Identify and promote the development of various subject-matter areas relevant to University Extension programs and to the adult education process through which such programs are developed. This is done through the joint appointment of specialists between the Division and various colleges and departments and, as well, by assignment of subject-matter specialties to Extension Division staff members.

Administration Department
In addition to responsibility for the day-to-day operations of the Extension Division, the Administration Department assists several provincial organizations in the operation of their educational programs.
1. The Department is responsible for the administration of the Saskatchewan 4-H program in co-operation with the Saskatchewan and Canada Departments of Agriculture. At present the curriculum offers rural young people a choice of 75 educational projects in 35 subject-matter areas, embracing such fields as agriculture, homemaking, leadership, career exploration, science, international study, and many others. The Department conducts provincial 4-H events, provides reference material for leaders and projects, and evaluates the program. Leadership training is offered through the Division's Leadership Development Program. Young people are given opportunities through the 4-H club program for travel, scholarships, camping, and participation in community projects.
   Youth education specialists in the Extension Division offer consultation and training assistance to organizations or agencies interested in program and leadership development. Information on this program is available through the local offices of the agricultural representative or through the Administration Department of the Extension Division.
2. The Department assists the Saskatchewan Women's Institutes in administering their provincial programs.

3. The Department assists the Saskatchewan Agricultural and Horticultural Societies in administering their provincial programs.
4. The Department assists the Canadian Association for Adult Education, Saskatchewan Division, in conducting its annual program.

For film service, requests should be directed to the Division of Audio-Visual Services, University of Saskatchewan. Films on a wide range of topics are available, e.g., world affairs, health and welfare, industry and labor, citizenship and the community, travel, arts, music, and other topics.

Credit Programs

Summer School

The regular Summer School of the University meets annually from early July to mid-August. Courses of study are offered for undergraduates who are proceeding to a degree and for teachers who may wish to improve their professional qualifications. Courses usually offered in the Summer School are undergraduate classes in Arts and Science and in Education. A limited number of classes are also offered in the Colleges of Commerce, Home Economics, Physical Education, and Graduate Studies. Registration deadline is June 1. Accommodation in the University Halls will be open to all registered students of the Summer School who are enrolled in classes. Instruction is provided by members of the University faculty and visiting lecturers who are invited to join the Summer School staff.

Intersession

Intersession meets during May and June. At this session a number of classes are offered for undergraduates in Arts and Science, Commerce, Education, Home Economics, Pharmacy, and Physical Education.

Evening Classes

A number of evening credit classes are offered in Agriculture, Arts and Science, Commerce, Computational Science, Education, and Home Economics. A separate calendar which outlines the details is available on request.

Off-Campus Classes

A limited number of credit classes in Education, English, Geography, Psychology, and Sociology are offered in centres other than Saskatoon. These classes are generally held on Saturdays in centres such as Melfort, Nipawin, North Battleford, and Prince Albert. A calendar is available on request.

CANADA DEPARTMENT OF AGRICULTURE

Research Branch

The Research Branch of the Canada Department of Agriculture maintains four research stations and one experimental farm in Saskatchewan. Mail enquiries should be directed to each as follows:

C.D.A. Research Station, University of Saskatchewan, Saskatoon.

C.D.A. Research Station, Regina, Swift Current, or Melfort.

C.D.A. Experimental Farm, Indian Head.

Each of these establishments conducts research on a variety of agricultural problems. For information on the following subjects contact one or more of the establishments listed.

Agricultural Engineering—Swift Current.

Cereal Crops—Indian Head, Melfort, Regina, Saskatoon, and Swift Current.

Forage Crops—Saskatoon, Indian Head, Melfort, and Swift Current.

Horticulture—Indian Head, Melfort, and Swift Current.

Insects—Saskatoon.

Livestock—Melfort and Swift Current.

Pastures—Melfort, Swift Current, and Saskatoon.

Plant Diseases—Saskatoon.

Poultry—Swift Current.

Soil Classification and Mapping—Saskatoon.

Soil and Crop Management—Indian Head, Melfort, Saskatoon, and Swift Current.

Soil Fertility—Indian Head, Melfort, Saskatoon, and Swift Current.

Weed Control—Indian Head, Melfort, Regina, Saskatoon, and Swift Current.

Production and Marketing Branch

The Production and Marketing Branch of the Canada Department of Agriculture carries on protective and regulatory services relating to agriculture. This includes matters such as health of animals, grading agricultural products, supervision of the marketing of agricultural products, regulation of the seed trade and inspection of imports and exports of agricultural products for insect pests and diseases. To carry out this work the Production and Marketing Branch has several divisions, with offices throughout Canada. Units in Saskatchewan are listed below.

Dairy Products Division—811 Motherwell Building, Regina; 202 Federal Building, Saskatoon; and 113 Federal Building, Yorkton.
Grading and inspection of dairy products.

Fruit and Vegetable Division—819 Motherwell Building, Regina; 202 Federal Building, Saskatoon.
Inspection services under the Fruit, Vegetable and Honey Act. Honey-grading and inspection regulations under the Saskatchewan Vegetable and Honey Sales Act. Market information.

Livestock Division—District Supervisor, 841 Motherwell Building, Regina.
Swine Improvement Policies, Record of Performance for Purebred Swine. Bull Loaning Policy. Record of Performance for Dairy Cattle. Federal Assistance to Horse Breeding. Sheep Improvement Policies.

Livestock Officers—Stockyards in Regina, Saskatoon, Moose Jaw, and Prince Albert.
Grading of hog, beef, lamb, mutton, and veal carcasses. Grading of wool. Supervision trading in stockyards. Information regarding volume of livestock sales, prices, and related items.

Plant Products Division—413 London Building, Saskatoon; 841 Motherwell Building, Regina.
Enforcement of the Seeds Act, Feeding Stuffs Act, Fertilizer Act, Pest Control Products Act, Inspection and Sales Act (binder twine) and Hay and Straw Inspection Act. Inspection of pedigreed crops and seed. Seed testing and seed grading. Production reporting.
Sub offices located at Yorkton, Nipawin, and Prince Albert.

Plant Protection Division—817 Motherwell Building, Regina.
Inspection of imports and exports of plants and plant products for insect pests and plant diseases. Seed potato certification.

Poultry Division—820 Motherwell Building, Regina. Production Section—Regina and Saskatoon.
Record of Performance for Poultry. Inspection of registered hatcheries.

Registration of Purebred Animals—Correspondence concerning the registration of purebred animals should be sent to the following:
Holstein-Friesian Cattle—The Secretary, Holstein-Friesian Association, Brantford, Ontario.
Animals of all other breeds—The Accountant, Canadian National Livestock Records, Ottawa, Ontario.

Health of Animals Branch

The Health of Animals Branch administers the Animal Contagious Diseases Act, the Meat Inspection Act, and the Humane Slaughter of Food Animals Act, and operates laboratories for the study of animal diseases.

Contagious Diseases Division—828 Motherwell Building, Regina.
Controls contagious diseases of animals through preventive measures of inspection and quarantine of imported livestock and restricted commodities, e.g., meat, farm products, through conducting disease eradication programs, notably bovine tuberculosis, brucellosis, and Johne's disease; through control and eradication of outbreaks of serious animal diseases; and through inspection and certification for health of livestock for export.

Meat Inspection Division—828 Motherwell Building, Regina.
Conducts ante-mortem and continuous post-mortem examinations of animals slaughtered at packing plants that market their meat products outside of this province; ensures maintenance of sanitary standards during processing of the products, accurate labelling, and proper usage of ingredients and preservatives.

Animal Pathology Division—901 Motherwell Building, Regina.
Conducts research and investigations on infectious diseases of animals; produces such products as tuberculosis and *Brucella abortus* antigen, for use of the Health of Animals Branch in the control and elimination of tuberculosis, brucellosis, etc.; provides a diagnostic service to the other divisions of the Branch, and to the livestock industry in general.

Economics Branch—Motherwell Building, Regina
Research work is conducted in land utilization, farm management, and marketing of agricultural products. Information pertaining to studies is made available on request.

Special Act Administrations

Prairie Farm Assistance Administration—418 Federal Building, Regina.
Provision for benefit payments to farmers having low crop yields because of drought, insect damage, and other causes.

Farm Credit Corporation—Saskatchewan Branch Office, 701 Midtown Centre, Regina, Saskatchewan.
Administers the Farm Credit Act and the Farm Machinery Syndicates Credit Act. Counselling services provided by Credit Advisors located at Humboldt, Saskatoon, Watrous, Wynyard, Melfort, Nipawin, Prince Albert, Spiritwood, Tisdale, Kindersley, Meadow Lake, North Battleford, Unity, Estevan, Carlyle, Weyburn, Indian Head, Regina, Moose Jaw, Assiniboia, Shaunavon, Swift Current, and Rosetown.

***Prairie Farm Rehabilitation Administration**—Motherwell Building, Regina.
Administers the Prairie Farm Rehabilitation Act and special votes of Parliament concerned with soil and water conservation, irrigation, and land utilization in Western Canada.

Under the P.F.R.A. Water Development Program, agricultural, engineering, and financial assistance is made available to farmers, for the construction of individual farm water storage and irrigation projects. Similar assistance is provided jointly with the provincial government for the design and construction of community water-use projects. Supervision of these services in Saskatchewan is through the P.F.R.A. head office in Regina, a regional supervisor and district offices at Swift Current, Maple Creek, Shaunavon, Gravelbourg, Moose Jaw, Weyburn, Melville, Melfort, Biggar, and North Battleford.

The P.F.R.A. Tree Nursery, Indian Head, is operated and administered under the Water Development Program. All distribution of tree seedlings is made from Indian Head. Distribution of deciduous and conifer seedlings is free of charge, except for shipping costs, to farmers who apply to use them as a farm or field shelterbelt.

The P.F.R.A. Land Utilization Program which mainly involves the construction, organization, and operation of community pastures in Saskatchewan and Manitoba is administered from P.F.R.A. headquarters in Regina, and in Saskatchewan from district offices at Weyburn, Saskatoon, Kindersley, and Swift Current. Administration of several irrigation projects in Southwestern Saskatchewan is from Swift Current. The Demonstration Farm at Outlook provides information on irrigation practices applicable to the developments in that area. Engineering investigations, design of works, and supervision of construction of major water-use projects are administered from P.F.R.A. headquarters in Regina, and from Saskatchewan regional offices in Regina and Swift Current.
The P.F.R.A. Soils Mechanics Division offices and laboratories are located on the University Campus at Saskatoon.

The Agricultural Rehabilitation and Development Act—A regional office covering the four Western provinces is located in Winnipeg. The Act enables the Government of Canada to enter into agreements with provincial governments for joint programs of alternate land use, soil and water conservation, and rural development aimed at providing increased income and employment opportunities for rural people.

The agreement with the provinces enables joint participation through: 1. Research. 2. Land Use and Farm Adjustment. 3. Rehabilitation. 4. Rural Development Staff and Training Services. 5. Rural Development Areas. 6. Special Rural Development Areas. 7. Public Information Services. 8. Soil and Water Conservation.

The Act also provides for the federal government to initiate or participate in studies or research on its own or through provincial governments, universities, or independent agencies.

*As of April 1, 1969, Prairie Farm Rehabilitation Administration was transferred to Department of Regional Economic Expansion.

THE SASKATCHEWAN AGRICULTURAL SERVICES CO-ORDINATING COMMITTEE

The Saskatchewan Agricultural Services Co-ordinating Committee (S.A.S.C.C.) is made up of representatives of the Provincial and Federal Departments of Agriculture, the University College of Agriculture, the Western College of Veterinary Medicine, and the Extension Division. The aim of S.A.S.C.C. is to co-ordinate research and extension in agriculture among the agencies engaged in these activities.

Since agricultural research and extension have many aspects, the experts in various subject-matter areas are organized into advisory councils. The advisory councils are working committees involved with making unified recommendations to farmers, preparing publications, and the co-ordination of research and extension programs and policies. Items requiring the consideration of the University or provincial or federal governments are directed by the advisory councils to the S.A.S.C. Committee. S.A.S.C.C. also attempts to co-ordinate the work of various advisory councils.

A brochure on S.A.S.C.C. may be obtained from the Extension Division, University of Saskatchewan, Saskatoon.

FARM BULLETINS (Selected List)

Canada Department of Agriculture, Information Division, Ottawa

List of Publications Available from Information Division, Canada Department of Agriculture, Ottawa.

Agricultural Economics

Canadian Meat Packing and Farmer Organizations.
Livestock, Meat and Farmers.
Selected Agricultural and Related Statistics.
Selected Livestock Statistics.

Agricultural Engineering

Agricultural Machinery Costs. Publ. 1291. 1966.
Blade Cultivators, Their Operation and Adjustment. Publ. 879. 1953.
Catalogue of Plans: Beef Cattle Housing and Equipment. 1970.
Dairy Cattle Housing and Equipment. 1966.
Grain Storage Structures and Equipment. 1967.
Poultry Housing and Equipment. 1965.
Special Structures and Equipment (Garages, Machine Sheds, Animal Cages, Greenhouses, Septic Tanks, etc.). 1966.
Comparison of Power Costs of Tractors. Publ. 1040. 1967.
Farm Sprayers. Publ. 1157.
Farm Trailers, Wagons and Racks. Publ. 830. 1966.
Growing of Irrigated Crops in Alberta. Publ. 1152. 1962.
Irrigated Pastures in Southern Alberta. Publ. 1160. 1964.
Irrigation Water, Its Use and Application. Publ. 1199. 1966.
Seed Cleaners and Separators. Publ. 1061. 1960.
Tractor Problems With Mounted Tillage Implements. Publ. 999. 1957.

Dairying

Grass Silage in Dairy Cattle Rations. Publ. 929. 1955.
High Quality Milk. Publ. 844. 1962.

Foods, Home Canning, and Freezing

Apples. Publ. 1402. 1970.
The Art of Making Sandwiches. Publ. 1053. 1959.
Barbecue Cooking. Publ. 1294. 1966.
Buy By Grade. Publ. 1305. 1966.
Cereals. 1960.
Freezing Foods. Publ. 892. 1965.
Growing Savory Herbs. Publ. 1158. 1963.
Home Canning of Fruits and Vegetables. 1965.
Jams, Jellies and Pickles. Publ. 992. 1956.
Making Blueberry Wine at Home. Publ. 1206. 1964.
Meat—How to Buy, How to Cook. Publ. 971. 80 pp. Illus. 1968.
(*obtainable only from the Queen's Printer*—$1.00).
Mushroom Collecting for Beginners. Publ. 861. 1958.
Potatoes. Publ. 1058. 1959.
Salads. Publ. 1050. 1964.
Salad Dressings. 1964.
Turkey for Everyone. (folder) 1968.

Forage Crops

Alfalfa in Canada. Publ. 1377.
Brush Control in Western Canada. Publ. 1240.
Common Grasses of the Canadian Prairies. Publ. 1413.
Creeping Red Fescue. Publ. 1122.
Crested Wheatgrass. Publ. 986.
Domestication of Alfalfa Leaf-Cutter Bees. Publ. 1313.
Forage Crops for Irrigated Land in Southern Alberta. Publ. 1132.
Growing Corn. Publ. 1025.
Legume Inoculation. Publ. 1299.
Licensed Varieties of Cultivated Grasses and Legumes. Publ. 1405.
Producing Certified Seed of Bromegrass in Western Canada. Publ. 866.
99 Range Forage Plants of the Canadian Prairies. Publ. 964.
Reed Canary Grass. Publ. 805.
Row Spacing Affects Yields of Forage Grasses in the Brown Soil Zone of Saskatchewan. Publ. 1100.
Russian Wild Ryegrass for Western Canada. Publ. 991.
Sanfoin. Mimeo. Lethbridge.
Seeding Prairie Rangelands. Economics Branch.
Slough Drainage—Methods and Costs. Mimeo. Circular.
Soil Salinity and Drainage Problems. Publ. 1314.
Solonetzic Soils and Their Management. Publ. 1391.
Sweet Clover in Western Canada. Publ. 998.
What You Should Know About Seeds. Publ. 1412.

Grain Crops

Corn for Livestock and Poultry. Publ. 1358. 1968.
Crop Rotation and Productivity. Publ. 1376. 1969.
Damp Grain. Publ. 1398. 1969.
Growing Flax. Publ. 545. 1968.
Growing Irrigated Crops on the Canadian Prairies. Publ. 1400. 1969.
Rogues and Roguing Cereal Crops. Publ. 1423. 1970.
What You Should Know About Wheat. Publ. 1386. 1969.
Winter Wheat Production in Western Canada. Publ. 1056. 1968.

Horticulture

Annual Flowers for Canadian Gardens. Publ. 796. 1966.
Catalogue of Plans, Fruit and Vegetable Buildings and Equipment.
Chemical Control of Insects in Gardens, Yards and Shelterbelts.
Common Scab of Potato. Publ. 953. 1964.
Control of the Currant Fruit Fly. Publ. 1143. 1967.
Control of the European Corn Borer in Sweet Corn. Publ. 1300. 1966.
Control of Mice, Rabbits and Deer in Orchards. Publ. 1115. 1965.
Control of Turnip Maggot in Rutabagas in Saskatchewan. Publ. 950. 1955.
Culture of Ornamental Trees for Canadian Gardens. Publ. 994. 1957.
Descriptive Notes on Herbaceous Perennials. Publ. 968. 1956.
Diseases and Pests of Turfgrass in the Prairie Provinces. Publ .1247.
Fertilizer Schedules for Greenhouse Cucumbers Southwestern Ontario. Publ. 1394.
Fertilizer Schedules for Greenhouse Tomatoes Southwestern Ontario.
Flowering Bulbs for Canadian Gardens. Publ. 996. 1962.
Fruit Tree Propagation. Publ. 1289. 60 pp. Illus. 1968.
Garden Rose Growing. Publ. 908. 1960.
Geraniums. Publ. 1411. 1970.
Growing Fuchsias. Publ. 1385. 1969.
Growing Gladiolus. Publ. 1229. 1965.
Growing Herbaceous Perennials. Publ. 970. 1956.
Growing Vegetables in the Prairie Garden. Publ. 1033. 1969.
Handbook on the Storage of Fruits and Vegetables for Farm and Commercial Use. Publ. 1260. 52 pp. 1967.
Handling Potatoes from Grower to Retailer. (folder) Publ. 1359. 1966.
Hardy Asters for the Autumn Garden. Publ. 1271. 1966.
Hedges for the Prairies. Publ. 1153. 1962.
How to Make a Plastic Crop Shelter or Greenhouse. Publ. 1337. 1967.
How to Grow Mushrooms. Publ. 1205. 1965.
Irrigating the Prairie Home Garden. Publ. 851.
Judging Standards for Horticultural Shows. Publ. 1395. 1969.
Lawns. Publ. 1163. 1967.
Lythrums for Home Gardens. Publ. 1285. 1967.
Pruning Apple Trees. 4 pp. 1967.
The Raspberry Crown Borer. Publ. 1268. 1966.
The Rock Garden. Publ. 1243. 1966.
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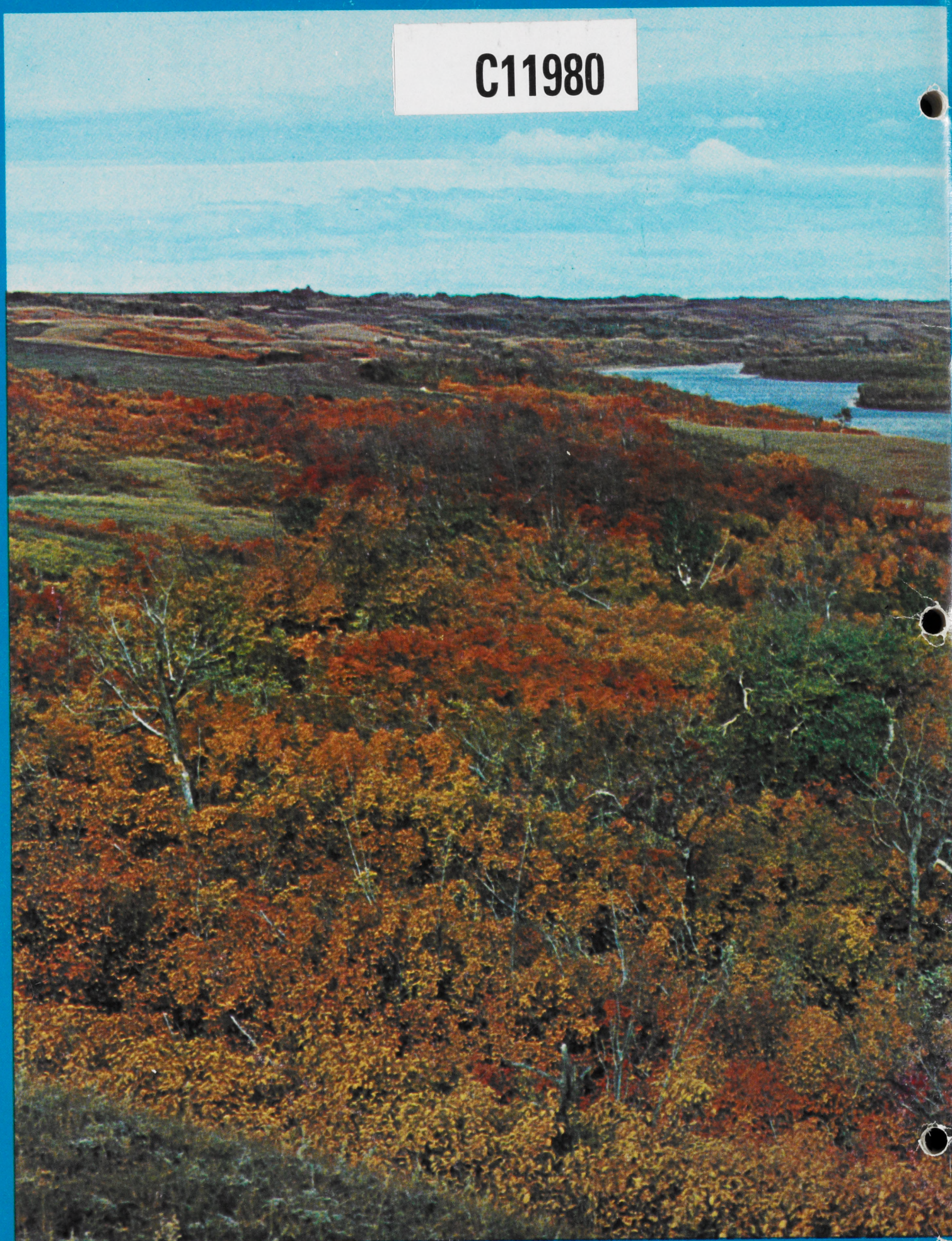

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